OPERATION AND MAINTENANCE MANUAL

for

Model 8608/8606/8607

BROADBAND ISOTROPIC RADIATION MONITORS

Equipment Serial No.

GENERAL ELECTRIC
INSTRUMENTATION & COMMUNICATION
1200 KONA DRIVE
COMPTON, CA 90220
(213) 642-5317

U.S. Patent Nos.

4023093	DES 223293
3641439	G.B. 1326243
1357294	DES 262360

Canada 950041
Additional Foreign Patents

narda

PRECISION MICROWAVE AND RF TEST EQUIPMENT

THE NARDA MICROWAVE CORPORATION, HAUPPAUGE, NEW YORK 11788

1182/325LCI
REVISED 11/82
REV 1

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SECTION I

GENERAL DESCRIPTION

1-1. INTRODUCTION

1-2. This manual contains complete instructions for the operation of the Model 8608 BROADBAND ISOTROPIC RADIATION MONITOR as well as the Models 8606 and 8607 RADIATION MONITORS which are abridged versions of the 8608. The 8606, shown in figure 1-1, is manufactured by the Narda Microwave Corporation, Hauppauge, New York 11788. This manual includes a general description of the equipment, operating instructions and servicing procedures.

1-3. DESCRIPTION 8608

1-4. Model 8608 is a Broadband Isotropic Radiation Monitoring System which covers the frequency range from 10 MHz to 26 GHz with only two probes. One probe covers the range from 10 MHz to 300 MHz. The frequency sensitivity is ±0.5 dB from 13 MHz to 200 MHz and 2 dB maximun from 10 MHz to 300 MHz. The frequency range from 300 MHz to 26 GHz is covered by a second probe. Its frequency sensitivity over this range is +0.75 dB, −3 dB.
From 1 to 12 GHz the frequency sensitivity is ±0.75 dB.

Two probes in each of these frequency ranges provide additional dynamic range. Probes are available with a dynamic range of .02 to 20 mW/cm^2 or 0.1 to 100 mW/cm^2. Each probe has a preamplifier built into the handle. This, together with thin film coatings about the probe, eliminates the effects of static charges and cable modulation. The low frequency 10 to 300 MHz probe responds to the H field. The high frequency probe responds to the E field. These probes are essentially independent of polarization or direction of incidence of energy. Deviation in readings due to these characteristics is ±0.5 dB maximum.

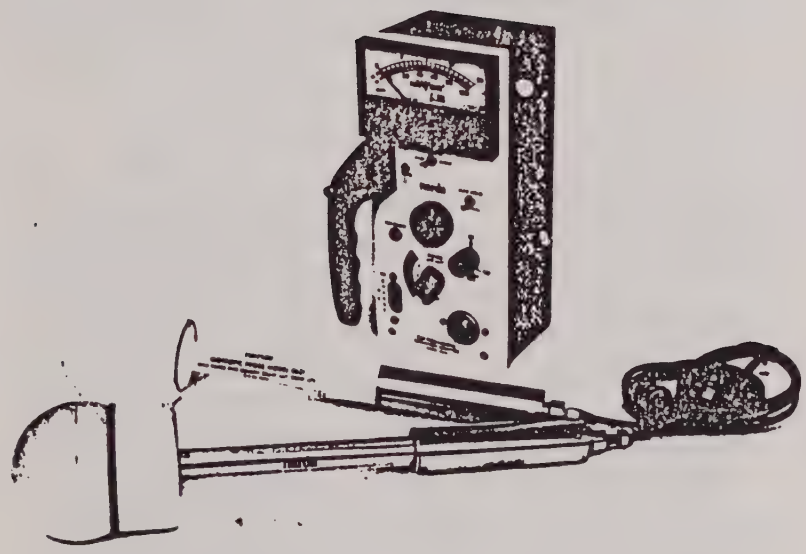

Figure 1-1. Model 8608 BROADBAND ISOTROPIC RADIATION MONITOR

1-5. The metering instrument is battery operated from an internal rechargeable battery. The unit can also be operated from AC mains of 115 V, or 230 volts. An auto zero permits the unit to be zeroed by simply pressing a button. In addition to its normal mode of operation (where instantaneous indications of the monitored field are displayed), a "Max Hold" mode is provided. In this mode of operation the maximun power density surveyed will be indicated and maintained until the auto-zero button is pressed.

1-6. DESCRIPTION 8606 (High Frequency)

1-7. Model 8606 is a high frequency abridged version of Model 8608. The unit covers the frequency range from 300 MHz to 26 GHz. Frequency sensitivity over this range is +.75 dB, -3 dB. From 1 to 12 GHz the frequency sensitivity is ±0.75 dB. Probes are available with a dynamic range of .02 to 20 mW/cm^2 or .1 to 100 mW/cm^2. Each probe has a pre-amplifier built into the handle. This feature, together with a thin film resistive coating, eleminates the effects of static charges and cable modulation. The probes respond to the electric field and are independent of polarization or direction of incident energy. Deviations due to these latter characteristics are less than ±0.5 dB for all orientations except when the handle is aligned with the E field.

1-8. Model 8606 utilizes the same meter as Model 8608. (Refer to paragraph 1-5).

1-9. DESCRIPTION 8607 (Low Frequency)

1-10. Model 8607 is a low frequency abridged version of Model 8608. The unit covers the frequency range from

10 MHz to 300 MHz. Frequency sensitivity over the 13 to 200 MHz range is ±0.5 dB. From 10 MHz to 300 MHz the frequency sensitivity is 2 dB maximum. Probes are available with a dynamic range of 0.02 to 20 mW/cm² or 0.1 to 100 mW/cm². Each probe has a preamplifier built into the handle. This feature together with a thin film resistive coating, eliminates the effects of static charges and cable modulation. The probes respond to the magnetic field and are independent of polarization or direction of incident energy. Deviations due to these latter characteristics are less than ±0.5dB.

1-11. Model 8607 utilizes the same meter as Models 8608 and 8606 (Refer to paragraph 1-5).

1-12. OPTIONAL PROBES

1-13. Two additional low frequency probes, Model 8652 and Model 8662 are available. These probes will extend the frequency range of the system down to 300 kHz. The model 8652 measures the magnetic field and covers the frequency range from 300 kHz to 10 MHz. The Model 8662 measures the electric field and covers the frequency range from 300 kHz to 300 MHz. The full scale equivalent power density for both of these probes is 200 mW/cm². A range decal and selector knob are provided to permit proper scaling when these probes are used with the Model 8616 meter.

1-14. EQUIPMENT SUPPLIED

1-15. Tables 1-1, 1-2, and 1-3 tabulate the equipment that is provided with Models 8608, 8607, and 8606.

Table 1-1. Equipment Supplied with Model 8608

Model 8616	Broadband Isotropic Radiation Meter
One Isotropic Low Frequency Probe; 10 MHz to 300 MHz	Model 8631, 20 mW/cm² Full scale OR Model 8633, 100 mW/cm² Full scale

Table 1-1 (Cont)

One Isotropic High Frequency Probe; 300 MHz to 26 GHz	Model 8621, 20 mW/cm² Full scale OR Model 8623, 100 mW/cm² Full scale
Battery	25 volt nickel cadmium rechargeable
Charging Cable	AC Line Cord
Probe Mount	Model 8630
Carrying Case	Houses meter and accessories and provides shielding from stray power density

Table 1-2. Equipment Supplied with Model 8607

Model 8616	Broadband Isotropic Radiation Meter
One Isotropic Low Frequency Probe; 10 MHz to 300 MHz	Model 8631, 20 mW/cm² Full scale OR Model 8633, 100 mW/cm² Full scale
Battery	25 volt nickel cadmium rechargeable
Charging Cable	AC Line Cord
Probe Mount	Model 8630
Carrying Case	Houses meter and accessories and provides shielding from stray power density

CAUTION

Overload levels for Peak and CW signals are given in Table 1-4; to prevent damage to the probes these levels should not be exceeded.

Table 1-3. Equipment Supplied with Model 8606

Model 8616	Broadband Isotropic Radiation Meter
One Isotropic High Frequency Probe; 300 MHz to 26 GHz	Model 8621, 20 mW/cm² Full scale OR Model 8623, 100 mW/cm² Full scale
Battery	25 volt nickel cadmium rechargeable
Charging Cable	AC Line Cord
Probe Mount	Model 8630
Carrying Case	Houses meter and accessories and provides shielding from stray power density

1-16. Optional probes are available for use with the meter. All probes and meters are interchangeable. Available probes are:

Model 8621
Model 8623
Model 8631
Model 8633
Model 8662
Model 8652

See Table 1-4, Probe specifications for details.

TABLE 1-4 PROBE SPECIFICATIONS

Probe Model	8662	8621	8623	8652	8631	8633
Type	ELECTRIC FIELD			MAGNETIC FIELD		
Freq. Range	.3 to 300 MHz	300 MHz to 26 GHz		.3 to 10 MHz	10 MHz to 300 GHz	
Power Ranges Full Scale (Equivalent Power Density)	2 20 mW cm^{-2} 200	.2 2 mW cm^{-2} 20	1 10 mW cm^{-2} 100	2 20 mW cm^{-2} 200	.2 2 mW cm^{-2} 20	1 10 mW cm^{-2} 100
Accuracy of Probe Calibration at Test Frequencies	±0.5 dB					
Isotropic Response		±0.5 dB				
Freq. Sensitivity .3 to 10 MHz				±0.5 dB		
.3 to 300 MHz	.3 + 1 dB					
10—300 MHz	±1 dB				2 dB Max Total Deviation	
13—200 MHz					±.5 dB	
1—12 GHz		±.75 dB				
.85—16 GHz		+.75—1 dB				
.3 to 26 GHz		+.75—1 dB				

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TABLE 1-4 PROBE SPECIFICATIONS

Probe Model	8662	8621	8623	8652	8631	8633
CW Overload *	600 mW/cm²	300 mW/cm²	1000 mW/cm²	600 mW/cm²	60 mW/cm²	300 mW/cm²
Peak Power *	600 W/cm²	60 W/cm²	300 W/cm²	600 W/cm²	60 W/cm²	300 W/cm²
Calibration Frequencies	.3, .5, 1.0, 3.0, 13.56, 27.12, 40.68, 100, 200, 300 MHz	.3, 1.7, 2.45, 4.0, 5.0, 6.0, 7.0, 8.2, 9.3, 10, 11, 18, 26 GHz		.3, .5, 1, 3, 10 MHz	10, 13.56, 27.12, 40.68, 50, 100, 200, 300	
Size Probe	17 ⅜" Long Including 4" Cup	15 ½" Long Including 4" Dia. Sphere		17 ¼" Long Including 4" Cup	16 ½" Long Including 3 ½" Dia. Sphere	
Cable	Four Feet Long					

*Operating and Non-Operating.
Observe measurement procedures described in section entitled "Pre-Operation" and "Operating Procedure" to avoid damage. When not in use, store probes in shielded case supplied to avoid accidental exposure to excessive fields.

1-17. MODEL 8616 METERING INSTRUMENT SPECIFICATIONS (See Table 1-5).

1-18. Model 8616 operates with any and all of the 8600 series probes. Calibration cards are supplied with each probe to provide correction factors for a number of frequencies over the operating band. Fasteners are attached to the back of each card and the side face of the 8616 meter. This allows the calibration cards to be fastened to the side of the meter for easy access to the calibration data of the probe in use. Cards may be removed easily and stored until needed.

Table 1-5. Specifications for 8616 Radiation Meter (excluding probes)

Dynamic range	30 dB
Full scale ranges (mW/cm^2)	0-0.2, 0-2, 0-20 and 0-1, 0-10, 0-100; and 0-2, 0-20, 0-200
Accuracy	±3%
Response Time (approx)	1 sec. in fast position 3 sec. in slow position
Recorder Output	+3 v nominal at Full scale into minimum load of 1000Ω
Power Density Alarm	An adjustable audible alarm pre-set by panel control for a percentage of full scale
Battery Type	25 volt rechargeable nickel-cadmium — 40 hours use time 2.5:1 use to charge time

Table 1-5 (Cont)

Additional Features	Automatic zero and maximum hold mode of operation
Size	10" x 4-1/4" x 4" (not including handle)
Weight	5.5 lbs.
Line operation and charging	115/230, 50 to 440 cps

NOTE

Model 8616 meters with serial numbers below 02001 will require modification for proper operation with 8631 and 8633 probes having serial numbers above 03002.

SECTION II

OPERATION

2-1. GENERAL

2-2. This section provides the functional control description, operating instructions and precautions for Models 8608, 8607 and 8606 BROADBAND ISOTROPIC RADIATION MONITORS.

2-3. PRELIMINARY INSPECTION

2-4. This unit was tested and inspected at the factory before shipment. Immediately after unpacking the equipment, visually inspect it for damage which may have occurred in transit. If there is any evidence of damage such as broken knobs, damaged meters, etc; immediately file a claim with the carrier for damage in transit.

2-5. The battery should be charged immediately after unpacking. Refer to paragraph 4-35 for proper charging procedure.

2-6. CONTROL PANEL DESCRIPTION (See figure 2-1.)

2-7. FRONT PANEL. Table 2-1 provides a complete functional description of all front panel controls and indicators.

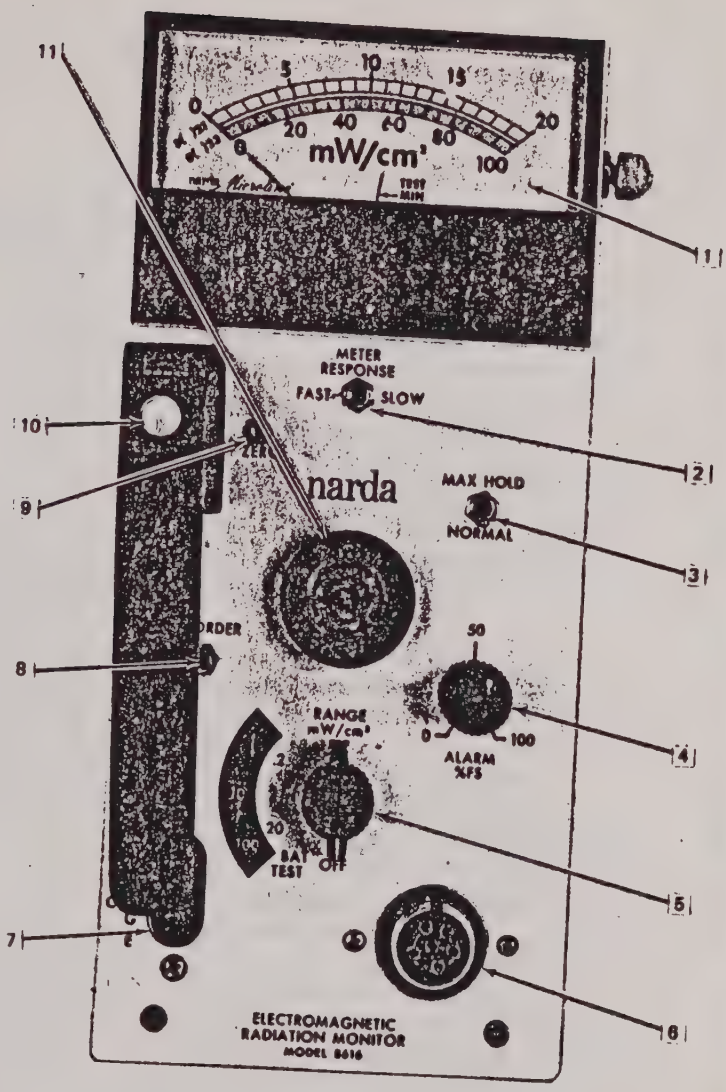


Figure 2-1. Model 8616 BROADBAND ISOTROPIC RADIATION MONITOR FRONT PANEL CONTROLS AND INDICATORS

Table 2-1. Front Panel Control and Indicator Functional Description (See Figure 2-1.)

Index No.	Control	Function
1	Meter	Indicates the level of the r-f field in mW/cm^2 as sensed by the Isotropic Probe (Refer to Table 1-4 for probe specifications.)
2	METER RESPONSE Switch	Provides means of selecting FAST or SLOW meter response.
3	MODE Switch	Selects either normal operation or Maximum Hold mode.
4	ALARM Control	Provides means of setting the percentage of full scale meter reading at which the audio alarm will sound to alert the operator of power density greater than the preset level.
5	RANGE Switch	Provides means of selecting either the 0.2/1; 2/10 or 20/100 mW/cm^2 sensitivity range.
6	Probe Connector	Provides for connection of Isotropic Probe.
7	AC Cable Plug Connector	Provides for connection to 115/230 vac electrical power for battery charging.

Table 2-1 (Cont)

8	RECORDER Jack	Provides for the connection of an external recorder. Provides 3 volts full scale.
9	ZERO Control	Provides for electrical adjustment of meter zero setting.
10	ZERO Button	Provides for automatic electrical setting of meter.
11	Alarm	Provides audio alarm to indicate when the preset power density level is exceeded.

2-8. GENERAL OPERATING INFORMATION

2-9. If the Isotropic Probe is very close to the radiating source, it should be oriented with the axis of the handle in line with the direction of travel of the suspected radiation (Probe pointing towards the source).

Narda probes are calibrated in a free space plane wave. The Models 8621 and 8623 high frequency probes cover the range of 0.3 to 26 GHz and mea ure the "E" electric field. Models 8631 and 8633 low frequency probes cover the 10 MHz to 300 MHz and measure the "H" magnetic field.

Two additional low frequency probes, Model 8652 and Model 8662 are available. These probes will extend the frequency range of the system down to 300 kHz. The Model 8652 measures the magnetic field and covers the frequency range from 300 kHz to 10 MHz. The Model 8662 measures the electric field and covers the frequency range from 300 kHz to 300 MHz. The full scale equivalent power density for both of these probes is 200 mW/cm^2. A range decal and selector knob are provided to permit proper scaling when these probes are used with the Model o616 meter.

CAUTION

Overload levels for Peak and CW signals are given in Table 1-4; to prevent damage to the probes these levels should not be exceeded.

The meter scale of the 8616 is marked in power density and truly applies in free space conditions where the ratio of the electric and the magnetic field is 377 ohms. At present, most specifications for radiation hazards use equivalent plane wave power density of mW/cm^2. Narda probes are therefore calibrated for meter readings in mW/cm^2. Table 2-2 is a conversion table for meter readings in mW/cm^2 to quantities in field strength squared, energy density, and power density in SI units, $Watts/Meter^2$. Table 2-3 is a conversion table from Power Density to Field Strength. Figures 2-2, and 2-3 are graphic charts of the field strength conversion. Table 2-4 lists the equations to make all necessary conversions.

NOTE

Calibration data is provided to specify correction factors for each probe at a number of frequencies over its operating band. This calibration data fastened on the probe handle.

WARNING

MODEL 8631, 8633 AND 8652 ISOTROPIC PROBES MAY PRODUCE ERRONEOUS READINGS IN RESPONSE TO OUT OF BAND SIGNALS ABOVE 300 MHz FOR 8631, 8633 AND 10 MHz FOR MODEL 8652.

NOTE

The American National Standards Institute, ANSI C95.1-1974 "Safety Level of Electromagnetic Radiation with Respect to Personnel" recommends:

For normal environmental conditions and for incident electromagnetic energy frequencies from 10 MHz to 100 GHz, the cw radiation protection guide is 10 mW/cm^2 and the equivalent free-space electric and magnetic field strengths are approximately 200 V/m rms and 0.5 A/m rms, respectively. For modulated fields, the power density and the squares of the field strengths are averaged over any 0.1 hour period; that is, none of the following should be exceeded, as averaged over any 0.1 hour period:

Mean Squared Electric
Field Strength — 40,000 V^2/m^2
Mean Squared Magnetic
Field Strength — 0.25 A^2/m^2
Power Density — 10 mW/cm^2
Energy Density — 1 mWh/cm^2

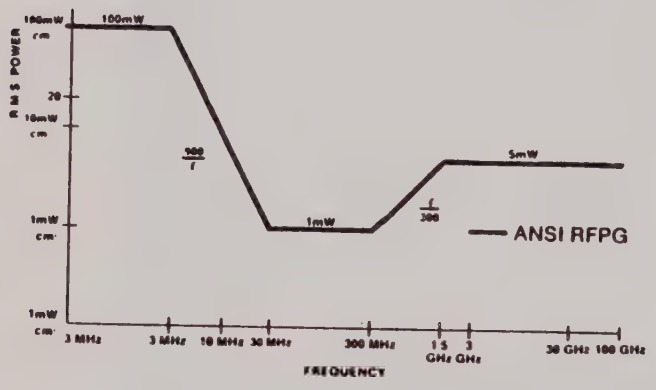
NOTE

The new ANSI radio frequency protection guide (C95.1-1982) covers the recommended levels for the 300 kHz to 100 GHz range. A summary of the new standard is included below for informational purposes.

Radiofrequency Protection Guides

Frequency Range	Power Density	E^2	H^2
MHz	mW/cm^2	V^2/m^2	A^2/m^2
0.3 – 3	100	400,000	2.5
3 – 30	$900/f^2$	$4,000\ (900/f^2)$	$0.025\ (900/f^2)$
30 – 300	1.0	4,000	0.025
300 – 1500	f/300	4,000 (f/300)	0.025 (f/300)
1500 – 100,000	5	20,000	0.125

Note: f is the frequency, in MHz. Below 300 MHz, both E and H fields must be measured independently



NOTE

Whole body exposure averaged over 0.1 hours. Both electric and magnetic fields must be measured separately below 300 MHz (near field exposure). For mixed or broadband fields consisting of a number of frequencies for which there are different values of the RFPG, the fraction of the RFPG incurred within each frequency interval shall be determined, and the sum of all such fractions shall not exceed unity.

Figure 2-2. Power Density to Electric Field Strength

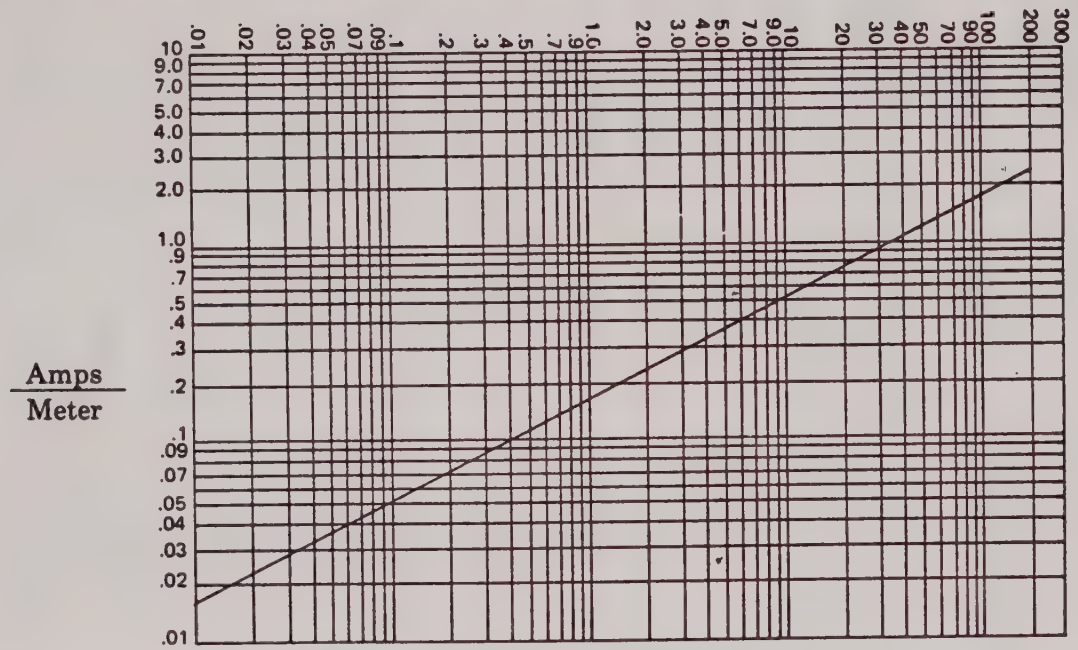


Figure 2-3. Power Density to Magnetic Field Strength

Table 2-2. Power Density Conversion Table

mW/cm^2	$\frac{E^2}{m^2}$	$\frac{A^2}{m^2}$	$\frac{*pJ}{cm^3}$	$\frac{watt}{m^2}$
	$\frac{(volts)^2}{(meter)^2}$	$\frac{(ampere)^2}{(meter)^2}$	$\frac{pico\ Joules}{cm^3}$	$\frac{watts}{Meter^2}$
Power Density	Mean squared Electric Field Strength	Mean squared Magnetic Field Strength	Total Energy Density	Power Density
100	376360	2.657	3.333	1000
50	188180	1.328	1.666	500
20	75272	.5314	.6666	200
10	37636	.2657	.3333	100
5	18818	.1328	.1666	50
2	7527.2	.05314	.06666	20
1	3763.6	.02657	.03333	10
.5	1881.8	.01328	.01666	5
.2	752.72	.005314	.006666	2
.1	376.36	.002657	.003333	1
.05	188.18	.001328	.001666	.5
.02	75.272	.0005314	.0006666	.2
.01	37.636	.0002657	.0003333	.1

*pJ/cm^3 = $I\mu J/m^3$

Table 2-3. Conversion of Power Density (Free Space) to Field Strength

Power Density mW/cm^2	Electric Field Strength Volts/meter	Magnetic Field Strength Amperes/meter
100	613.5	1.630
50	433.8	1.152
20	274	.7290
10	194	.5155
5	137	.3644
2	86.7	.2305
1	61.3	.1630
.5	43.4	.1152
.2	27.4	.0729
.1	19.4	.0515
.05	13.7	.0364
.02	8.67	.0230
.01	6.13	.0163

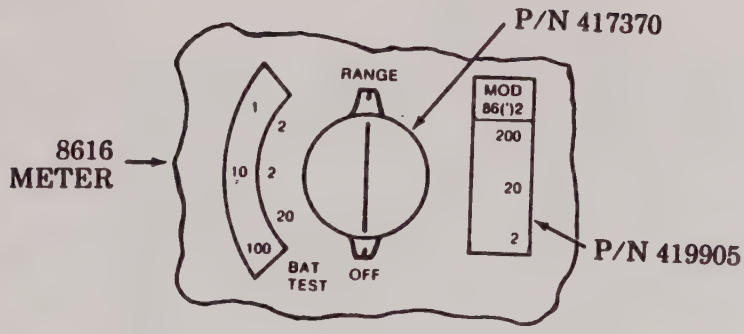
Table 2-4. Conversion of power density in mW/cm^2 to other parameters based upon free space conditions

$mW/cm^2 \times 10 = \frac{Watts}{(meter)^2} = \frac{W}{(M)^2}$	; power density
$mW/cm^2 \times 3763.6 = \frac{(Volt)^2}{(Meter)^2} = \frac{(E)^2}{(M)^2}$	;Mean squared Electric Field Strength
$mW/cm^2 \div 37.636 = \frac{(Amperes)^2}{(Meter)^2} = \frac{(A)^2}{(M)^2}$	;Mean squared Magnetic Field Strength
$mW/cm^2 \times .03333 = \frac{Pico\ Joules}{(cm)^3} = pJ/cm^2$	;Energy Density *
$\sqrt{mW/cm^2 \times 3763.6} = \frac{Volts}{Meter} = \frac{E}{M}$	;Electric Field Strength
$\sqrt{mW/cm^2 \div 37.636} = \frac{Amperes}{Meter} = \frac{A}{M}$	;Magnetic Field Strength

* 1 pJ/cm^3 = 1 uJ/m^3

2-10. PRELIMINARY INSTRUCTIONS (for 8662 and 8652 probes.)

2-11. If the 8662 or 8652 probe is to be used with the 8616 meter, fasten decal P/N 419905 to the right side of range switch as shown in sketch below. Remove knob on range switch using HEX wrench P/N 99104000 and replace with knob P/N 417370 using HEX wrench P/N 99104001.



2-12. PRE-OPERATION

CAUTION

Do not open case containing probes in an area where a high field may exist. See overload data in Table 1-4.

2-13. The following procedures should be performed before operating Models 8606/8607/8608 Broadband Isotropic Radiation Monitors.

a. Review all safety procedures before beginning a radiation survey.

b. Connect the desired Isotropic Probe to the meter by plugging the probe cable into the connector and tightening the locking collar.

c. Set the METER RESPONSE switch to the FAST position.

d. Set the ALARM control to the 100% position.

e. Set the MODE switch to the NORMAL position.

f. Set the RANGE switch to the BAT TEST position. Observe the meter indication; it should read above the TEST MIN mark on the meter face. If the meter reads below TEST MIN, connect charging line cord and recharge battery. Use the charge ratio is 2.5:1. Every 1 hour of charge time will allow 2.5 hours of use and a fully charged battery will therefore permit a minimum of 40 hours of use time. Sixteen hours of charge time will insure a fully charged battery. Model 8616 may be charged indefinately without any danger of damage to either the battery or meter.

CAUTION

The required charging power source voltage is indicated at the front panel line cord connector. It will indicate 115 or 230. This must correspond to the line source voltage. An internal charging switch may be reset to accomodate the available source.

g. Set range switch to 20/100/200 mW/cm^2 position.

h. Depress the ZERO pushbutton and hold for a "0" reading on the meter scale.

NOTE

When zeroing the meter, the Isotropic Probe should be placed in a zero density area to avoid stray power density pickup. If zero density area is not available, place the probe in the carrying case and partially close the cover when zeroing.

WARNING

IF METER CANNOT BE ZEROED, THE ISOTROPIC PROBE MAY BE DEFECTIVE. DO NOT USE A DEFECTIVE PROBE TO MEASURE POTENTIALLY HAZARDOUS RADIATION AREAS.

i. Set the RANGE switch to the 2/10/20 mW.cm^2 positio and press zero button for a "0" reading on meter scale.

j. Repeat zero operation (step i) on the 2/1/2 mW/cm² scale.

k. Reset ALARM control to the desired threshold value.

2-14. PEAK POWER RATINGS

CAUTION

(Operating and Non-Operating. When not in use, store probes in shielded case supplied to avoid accidental exposure to excessive fields.)

2-15. The maximum peak power rating of Model 8621 and 8631 Isotropic Probes is 60 W/cm². The peak power rating of the Model 8623 and 8633 is 300 W/cm² and 600 W/cm² for the Model 8652 and 8662.

2-16. When using the Model 8621 or 8631 Isotropic Probe to make measurements where radar duty factors are less than 0.00033, the full scale meter indication will exceed the 60 W/cm² maximum peak power density.

The maximum average power density indication with the Model 8621/8631 Probe is equal to 60 W/cm² times the duty factor and with the Model 8623/8633 Probe is equal to 300 W/cm² times the duty factor.

The nomograph on the next page may be used to determine the maximum average power density indication that corresponds to the peak power ratings of 60W/cm² and 300 W/cm², as follows:

The intersection of the duty factor line with the 60 W/cm² (heavy solid vertical) line for the Model 8621/8623 Probes, or the intersection of the duty factor line with the 300 W/cm² (heavy broken vertical) line for the Model 8623/8633 Probes, determines maximum average indicated power density. From the chart, the radar duty factors can be determined for the peak power density ratings of the probe.

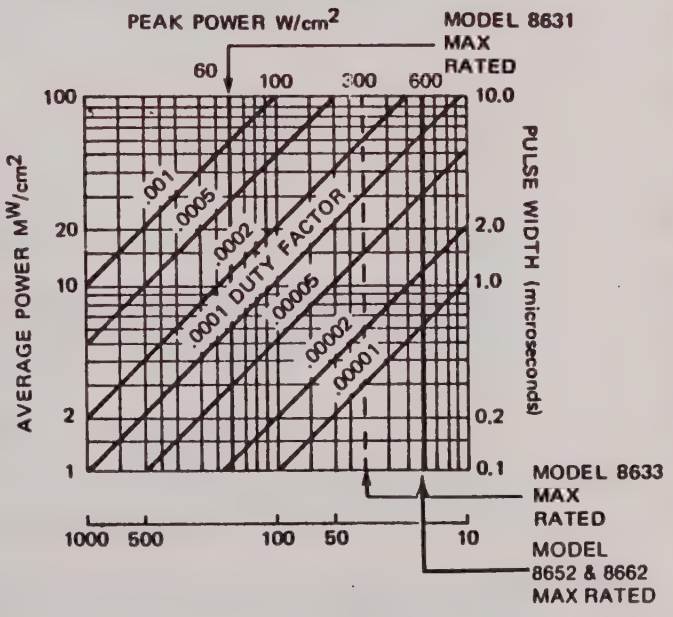
The duty factor is the product of the Pulse Width and Pulse Repetition Frequency and may be determined by locating the intersection of the Pulse Repetition Frequency and Pulse Width lines. Refer to Figure 2-4.

NOTE

It may be necessary to interpolate between adjacent duty factor lines.

2-17. STATIC CHARGED AREAS

2-18. Although the Isotropic Probe is equipped with a static charge shield, some meter deflection may be observed on the most sensitive scale when the probe is in motion in a high static charged area. This phenomena will not affect instrument accuracy. 'Accurate readings will be obtained when the probe is held motionless.



MAXIMUM ALLOWABLE
CW METER READINGS

	MODEL 8633 PROBE YELLOW COLOR 100 mW/cm^2 300 WATTS PEAK	MODEL 8631 PROBE WHITE COLOR 20 mW/cm^2 60 WATTS PEAK	MODEL 8662/ 8652 PROBES 200 mW/cm^2 600 WATTS PEAK
IF EMITTER DUTY CYCLE (P.W. x P.R.F.) is:	DO NOT EXCEED METER READINGS BELOW (X10 SCALE)	DO NOT EXCEED METER READINGS BELOW (X10 SCALE)	DO NOT EXCEED METER READINGS BELOW (X10 SCALE)
.00015 TO .00019	45 mW/cm^2	9 mW/cm^2	90
.0002 TO .00024	60	12	120
.00025 TO .00029	75	15	150
.00030 TO .00033	90	18	180
.00034 TO C.W.	FULL SCALE	FULL SCALE	FULL SCALE

Figure 2-4. Maximum Peak Power Density Nomograph

2-19. ZERO DRIFT

2-20. To minimize zero drift, allow approximately fifteen minutes of warm up time when operating the meter on the most sensitive range.

2-21. OPERATING PROCEDURE

2-22. Perform Pre-Operating procedures (paragraph 2-10) before attempting a radiation survey.

2-23. Always start to measure an unknown field as far from the source as possible. This will insure the safety of operating personnel.

Slowly introduce the isotropic probe into the unknown field. Hold the probe by its handle and point it toward the unit under test or radiating source. THE METER SHOULD BE HELD AWAY FROM THE SOURCE. Move the probe in a circular motion in the area of the radiation field. If location or direction of propagation is not known, the probe axis is best held at 45° to the ground (or horizontal surface) arm outstretched. Observe the meter reading. If the meter indication approaches full scale, withdraw the isotropic probe and set the RANGE switch to the 2/10/20 mW/cm^2 position. If the meter indication approaches full scale, withdraw the Isotropic Probe and set the range switch to the 20/100/200 position.

2-25. To insure maximum accuracy of meter reading, the probe should be rotated about its axis and the average of minimum and maximum readings obtained.

2-26. If the approximate power density of the field to be measured is not known, use the probe that has the highest power rating available.

WARNING

DO NOT ENTER A SUSPECTED RADIATION FIELD UNTIL A SAFE DENSITY LEVEL HAS BEEN ASCERTAINED! (REFER TO MAXIMUM PERMISSABLE EXPOSURE GUIDE IN USE.)

2-27. REMOTE OPERATION

2-28. Radiation measurements can be made without the need for personnel in the radiation field by use of the recorder output.

2-29. The recorder output provides a nominal 3 volt signal at full scale into a minimum load of 1000Ω.

2-30. Access to this recorder output is made through the miniature phone jack on the front panel. A shielded cable should be used to connect this recorder output to a recorder or indicating meter.

2-31. The recorder output is directly proportional to the meter indications. Calibration can be accomplished through use of potentiometer or gain control on a high impedance meter. The load resistance must be greater than 1000Ω. For power conservation, a value of 3000 or 10,000 ohms would be more desirable.

2-32. When used with a current operated indicator or recorder, a series resistor may be used to calibrate the remote indicator. Again, the load impedance must be greater than 1000Ω.

2-33. If the remote indicating equipment will be in the radiation field, this equipment should be shielded to insure proper operation. Position the cable normal to the "E" field to minimize perturbation of the field.

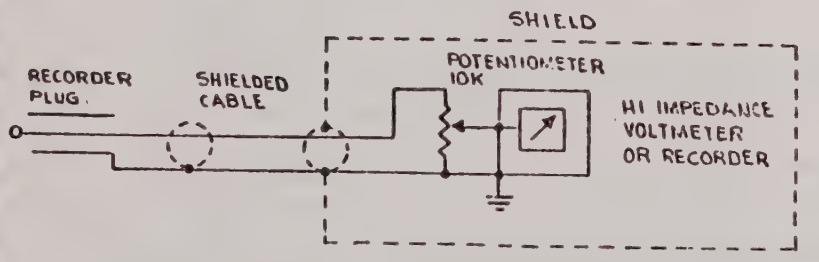


Figure 2-5. Remote Voltage Operated Indicator

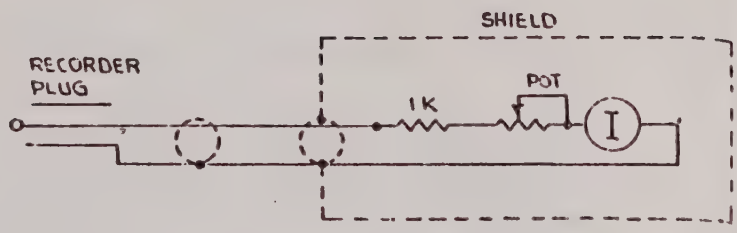


Figure 2-6. Remote Current Operated Indicator

2-34. A.C. OPERATION

2-35. Model 8616 Meter may be operated continuously from a 115 or 230 volt, 50 to 440 Hz power line.

2-36. The proper required voltage is indicated at the front panel A.C. Charge connector. If possible, the line cord should be kept out of the radiation field. If this is not possilbe, the cable should be oriented so that it is normal to the "E" electric field.

2-37. To change the required line voltage from one setting to the other, proceed as follows:

a. Remove cover from unit by removing six screws at back of case.

b. Set the 115/230 VAC Switch to the desired position.

c. Loosen two screws holding AC INPUT CONNECTOR. Place "Flag" over appropriate panel markings to indicate proper line voltage.

d. Connect the Charging Cable to the AC power source.

2-38. MAX-HOLD MODE OF OPERATION

2-39. With the MODE switch in the MAX HOLD position, the meter will indicate and retain the maximum value of power density that the probe has surveyed. This reading will be retained until the ZERO pushbutton is depressed. The drift rate for the MAX HOLD Mode is less than 0.3% of reading per minute. A MAX HOLD reading will be retained within 3% of its initial value after 10 minutes of elapsed time.

The recorder output corresponds to the meter indications and provides a retained output voltage of 3 volts ±10% at full scale meter indication. The recorder output will operate into a minimum load resistance of 1KΩ. The audible alarm continues to operate in its normal mode and will sound only during the period that the alarm threshold is exceeded. All of the preceding procedures are the same except that the mode switch is in the MAX HOLD rather than the NORMAL position.

2-40. It is NOT recommended that the meter be operated in MAX HOLD when the Meter Response switch is set to "Slow".

2-41. METER RESPONSE SELECTION

2-42. A front panel selector switch permits operation of the meter with a fast or slow response. In the SLOW position the meter will indicate 90% of the full value of a field having a step function characteristic in approximately 3 seconds. This integrating characteristic may be used to average time varying fields. In the FAST position, the meter responds to a step function field is less than 1 second. The FAST position is recommemded for all except the most unusual situations.

SECTION III

THEORY OF OPERATION

3-1. GENERAL

3-2. This section provides a brief description of the major circuits of Narda Models 8606, 8607 and 8608 Broadband Isotropic Radiation Monitors. Figure 3-1 is a simplified block diagram showing the principal circuits. Each circuit section and major individual circuits are explained.

3-3. As illustrated in Figure 3-1, Models 8606, 8607 and 8608 consist of a Probe Pre-amplifier with Variable Gain, Decade Adjustable Amplifier, Auto Zero, Max. Hold, Indicator and Battery Charging circuits.

3-4. The electromagnetic field being surveyed induces current in the thermoelectric elements in the probe. A low level d.c. thermoelectric voltage is generated and transmitted by resistive leads to variable gain pre-amplifier U101. The gain setting of this pre-amplifier establishes the calibration of the probe and the output of the pre-amplifier is connected by cable to the Model 8616 Meter.

Model 8616 comprises a decade adjustable amplifier, U2, which drives both an alarm section and indicator circuits. The alarm section consists of a comparator, U3, with a front panel adjustable threshold, a driver transister, Q5, and audible alarm, G1. The indicator circuits (U4, U5) provide a normal instantaneous indication or a maximum hold mode, which reads and retains the maximum signals supplied to the indicator.

In this mode the meter indicates the maximum power density surveyed. Operation of the ZERO pushbutton resets the circuits and activates the auto zero circuits in both normal and maximum hold modes of operation. These circuits utilize U1, Q1, and Q2 to sense the meter zero offset and supply a correction voltage to the input of the pre-amplifier.

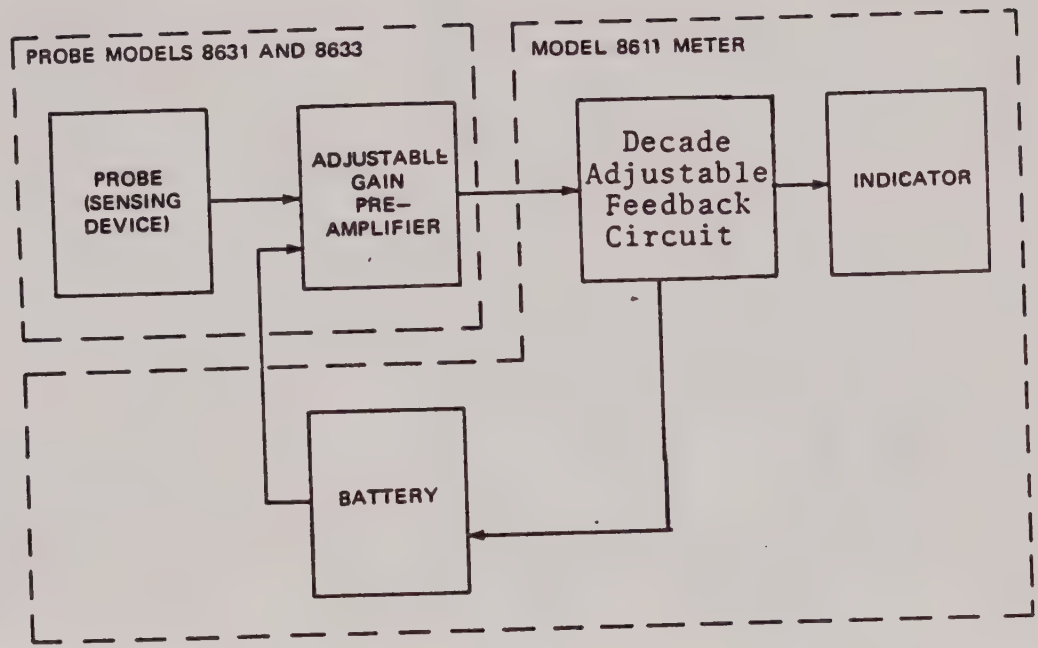


Figure 3-1. Simplified Block Diagram

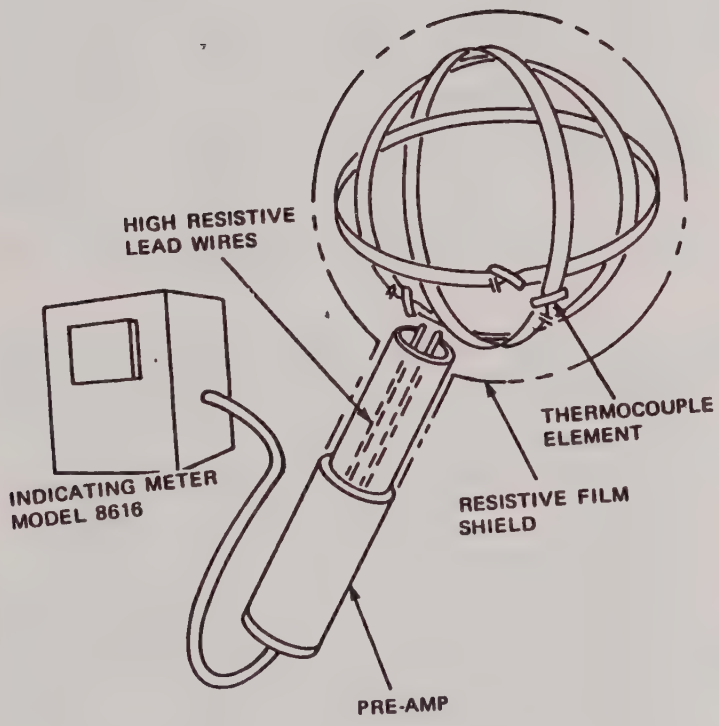


Figure 3-2. Low Frequency System Portrayal

3-5. BATTERY TEST

The battery test circuit ensures that the battery meets minimum operating requirements. When front panel TEST switch S101 is set to BAT, front panel meter M101 functions as a voltmeter and samples the battery voltage. A fully charged battery will provide a minimum of 40 hours of continuous use without re-charge. The use to charge ratio is 2.5:1 and a charge period of 1 hour is therefore required for every 2.5 hours of use. Extended life of the battery will be obtained by maintaining a fairly charged condition. Test indications should be read above the "Test Min" mark.

3-6. LOW-FREQUENCY PROBES, MODELS 8631, 8633, AND 8652

3-7. The 8631 and 8633 are low frequency probes covering the range of 10 MHz to 300 Mhz. The power density range of the 8631 is 20 mW/cm^2 maximum and the 8633 is 100 mW/cm^2 maximum full scale. The dynamic range for both probes is 30 dB below their full scale values; 20 mW/cm^2 to 20μW/cm^2 for the 8631 and 100 mW/cm^2 to 100μW/cm^2 for the 8633. Both probes are isotropic, and independent of polarization. They have true square law characteristics providing an accurate summation of power density present from multiple frequency sources. The Model 8652 covers the range of .3 MHz to 10 MHz. The power density range is 200 mW/cm^2 maximum full scale. The dynamic range is 30 dB below the full scale value: 200 mW/cm^2 to 200 μW/cm^2.

The probes are responsive to the "H" field. Each of the three mutually perpendicular coils in every probe has a diameter of 3.5 inches (8.9 cm) consists of multiple turns and is series resonated somewhat below the low frequency end of the band. Each coil is terminated with a thin film thermocouple element with a resistance of 30 ohms for the 8631, 8633 probes and 300 Ω for the Model 8652 probe.

A lumped equivalent circuit of a coil is shown in figure 3-3. C is the lumped resonating capacitor, L is the inductance of each turn (each turn is effectively shunted by its loop capacitance) and R_r is the radiation

resistance. Both the latter capacitance and the radiation resistance are extremely small and are negligable in the operating band. R is the resistance of the thin film thermocouple element and e is the induced equivalent open circuit voltage.

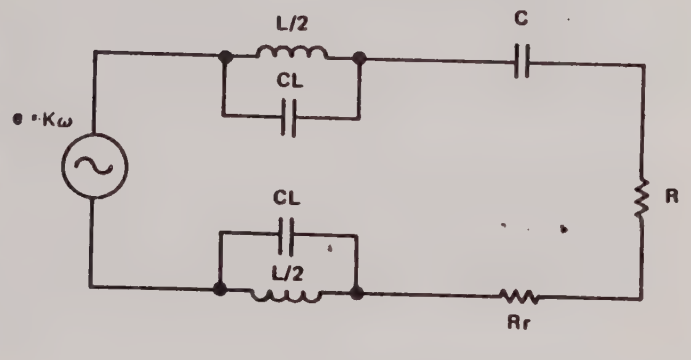


Figure 3-3. Models 8631, 8633 and 8652 Lumped Equivalent Circuit

Very high resistance monolithic leads interconnect the thermocouple elements in series and provide connection to the pre-amplifier in the probe handle.

The RF current induced by the "H" field dissipates power in the thermocouple elements, heats the hot junctions and provides a dc output voltage proportional to the square of the induced current.

The frequency sensitivity of the probe is flat to within ±0.5dB from 13 MHz to 200 MHz and exhibits an additional deviation in sensitivity of about 0.5dB between 200 and 300 MHz. This increase is because the probe has now become responsive to the "E" field. The Model 8652 is flat to ±0.5 dB from .3 to 10 MHz.

The pre-amplifier is connected to the elements by inflexible monolithic leads. This prevents the cable from modulating the signal if it is flexed or moved. The pre-amplifier, an extremely low noise operational amplifier with a minimum of zero offset characteristic, establishes the calibration of the probe.

A multiconductor shielded cable connects the pre-amp probe to the meter. This cable carries the pre-amp output, the power supply voltages and a correction voltage which is applied to the input of the amplifier to compensate for the zero offset. The cable disconnects at the Model 8616 front panel.

The entire probe is covered with a thin film, high resistive coating. This film is in the order of 0.5 megohm per square inch and provides a shield against electrostatic charges.

Complete interchangeability exists between any and all 8600 series Probes and the Model 8616 Meter.

3-8. HIGH FREQUENCY PROBES, MODELS 8621 AND 8623, AND 8662

3-9. Models 8621 and 8623 are high frequency probes which cover the range of 300 MHz to 26 GHz.

The power density range of the 8621 is 20 mW/cm^2 maximum and the 8623 is 100 mW/cm^2 maximum full scale. The dynamic range for both probes is 30 dB below their full scale values, ie, 20 $\mu W/cm^2$ to 20 mW/cm^2 for the 8621, 100 $\mu W/cm^2$ to 100 mW/cm^2 for the 8623.

Both probes are isotropic and independent of polarization. They exhibit true square law characteristics to provide an accurate summation of power density present from multiple frequency sources. Both units are responsive to the "E" field.

Each probe contains three mutually perpendicular lossy probe elements and provides a dc output signal proportional to the square of the electric field strength tangential to the element. The summation of the dc signals (from the three orthogonal probe elements) provides a measure of the total energy, or power density, independent of direction or polarization of the RF signals. Detectors for dc signal generation are thin-film thermocouples that provide true square-law output. The dc signal is proportional to the power dissipated in the thermocouple elements and the average energy density in the volume in which the elements are contained.

The pre-amplifier is located in the handle and connected to the elements by inflexible monolithic leads. This prevents the cable from modulating the signal if it is flexed or moved.

The pre-amplifier, an extremely low noise operational amplifier with a minimum of zero offset characteristic, establishes the calibration of the probe.

A multiconductor shielded cable connects the pre-amp probe to the 8616 meter. This cable carries the pre-amp output, the power supply voltages and a correction voltage which is applied to the input of the amplifier to compensate for the zero offset. The cable disconnects at the Model 8616 front panel.

The probe's broadband characteristics are obtained by distributing resistive thermocouple dipoles along the length of the element at spacings that will permit no resonant

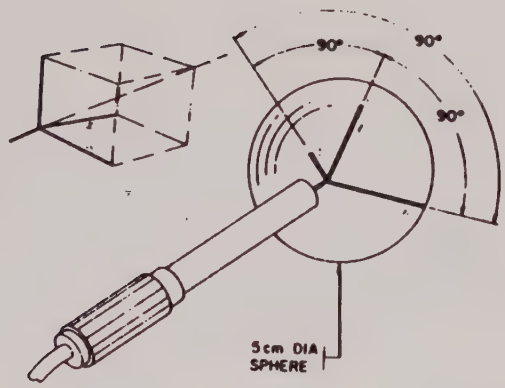


Figure 3-4. Relationship of the three mutually orthogonal probe elements. Probe elements are contained within a 5 cm sphere

lengths over the range of frequencies within which the probe is intended to operate. The spacing is less than 1/4λ of the highest frequency to be measured. The probe may be viewed as a group of series-connected, small resistive dipoles or as a very low Q resonant circuit.

A lumped equivalent schematic representation of a probe element is shown in Figure 3-5. R2 and C2 represent a terminal load of one of the probe elements (center-fed dipoles) and L1, C1 are the lumped equivalent inductance and capacitance of the probe element determined from the average characteristic impedance Z_0.

The entire probe is covered with a thin film, high resistive coating. This film is in the order of 0.5 megohm per square inch and provides a shield against electrostatic charges.

Model 8662 is similiar to the 8621 and 8623 probes with the exceptions that the sensors are conductive dipoles terminated in diode detectors. The broad bandwith is achieved thru the capacitive divider effect of achieved this dipole-diode combination. Some linearity correction is also provided for the upper portion of the high power density scale.

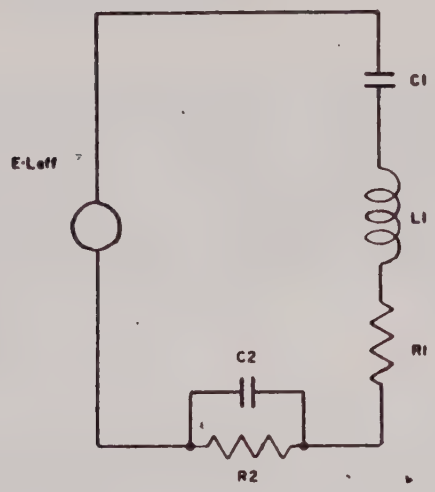


Figure 3-5. Lumped equivalent circuit of the probe with single elements relative to the total probe. R2 represents one of the distributed thermocouples

Complete interchangeability exists between any and all 8600 series Probes and the Model 8616 Meter.

3-10. INPUT AMPLIFIER

3-11. The output voltage of the probe pre-amplifier is transmitted through the panel connector to input amplifier U2. The gain of this amplifier is adjustable in decade steps from the front panel range switch. In the 20/100 mW/cm^2 position, the gain is unity. Gain increases in 20 dB steps as the range switch is set to 2/10 mW/cm^2 and .2/1 mW/cm^2 positions.

A change in gain is accomplished by altering the feedback voltage as established by a divider network consisting of R10 through R13. Resistor R20 is a zero offset and the adjustment control for the amplifier. Components R9 and C4 function as a low pass filter and CR3 and CR4 prevent lock-up of the amplifier if excessively large signals are applied. The amplifier output drives both the meter amplifier and the alarm circuits.

3-12. ALARM SECTION

3-13. Comparitor U3, and transistor Q5 provide the threshold circuitry and driver for audible alarm G1. The threshold value is set from front panel potentiometer R101. Panel calibration for this potentiometer is from 0 to 100% at full scale indication and resistor R18 provides for the adjustment of the calibration.

When the signal level from the output of U2 exceeds the threshold level, transition from a negative to positive voltage occurs at the output of U3. This drives Q5 into conduction, excites G1 and sounds the audible alarm. The alarm ceases when the signal level drops below the threshold and a polarity reversal again occurs at the output of U3. The operation of this circuit is independent of the Max-Hold/Normal switch.

3-14. INDICATOR CIRCUITS

3-15. The indicator circuits consist of amplifiers U4 and U5 and a meter. There are two modes of operation, Max-Hold and Normal. In the Normal mode, switch S103 shorts out CR11, and U4 and U5 operate as linear cascaded amplifiers with a gain of 30. This provides a recorder output at full-scale indication of 3 volts; minimum load resistance for the recorder is 1000Ω. In this mode the meter becomes the summing resistor of the feedback network and R28 is the feedback resistor.

3-19. POWER SUPPLY

3-20. The primary power source for the Model 8616 is a 24 volt center tapped, nickel-cadmium battery which supplies the ±12 volt circuits. Two single stage regulators provide stabilized ±7 volt supplies to reduce zero offset due to battery use and the resultant reduction in battery voltage. Components CR10 and Q3 function as the negative regulator and CR9 and Q4 function as the positive regulator. Both circuits are protected against shorting.

3-21. BATTERY CHARGING CIRCUIT

3-22. The battery charging circuit consists of power transformer T101, a standard bridge rectifier consisting of CR5 through CR8, and voltage limiting resistor R19. Standard 115 or 230 VAC is applied to power transformer T101 through AC Voltage selector switch S105 and line filter S101. The rectifier output voltage is applied to battery B1 in the proper polarity for battery charging and at a nominal rate of 50 ma.

The split primary windings of T101 are connected in series when AC Voltage selector switch S105 is in the 230 VAC position and in parallel when the switch is in the 115 V position. The front panel flag should be repositioned to indicate the line voltage corresponding to the setting of this switch.

The charger may be operated indefinately without damage to the battery and the meter may be operated during charging. This results in a reduced charging time. Use to charge ratio is 2.5:1, therefore, every one hour of charge time will allow 2.5 hours of use. Further, sixteen hours of charge time will insure a fully charged battery and a fully charged battery will permit a minimum of 40 hours of use time. The battery should be maintained in a relatively charged condition to ensure maximum life.

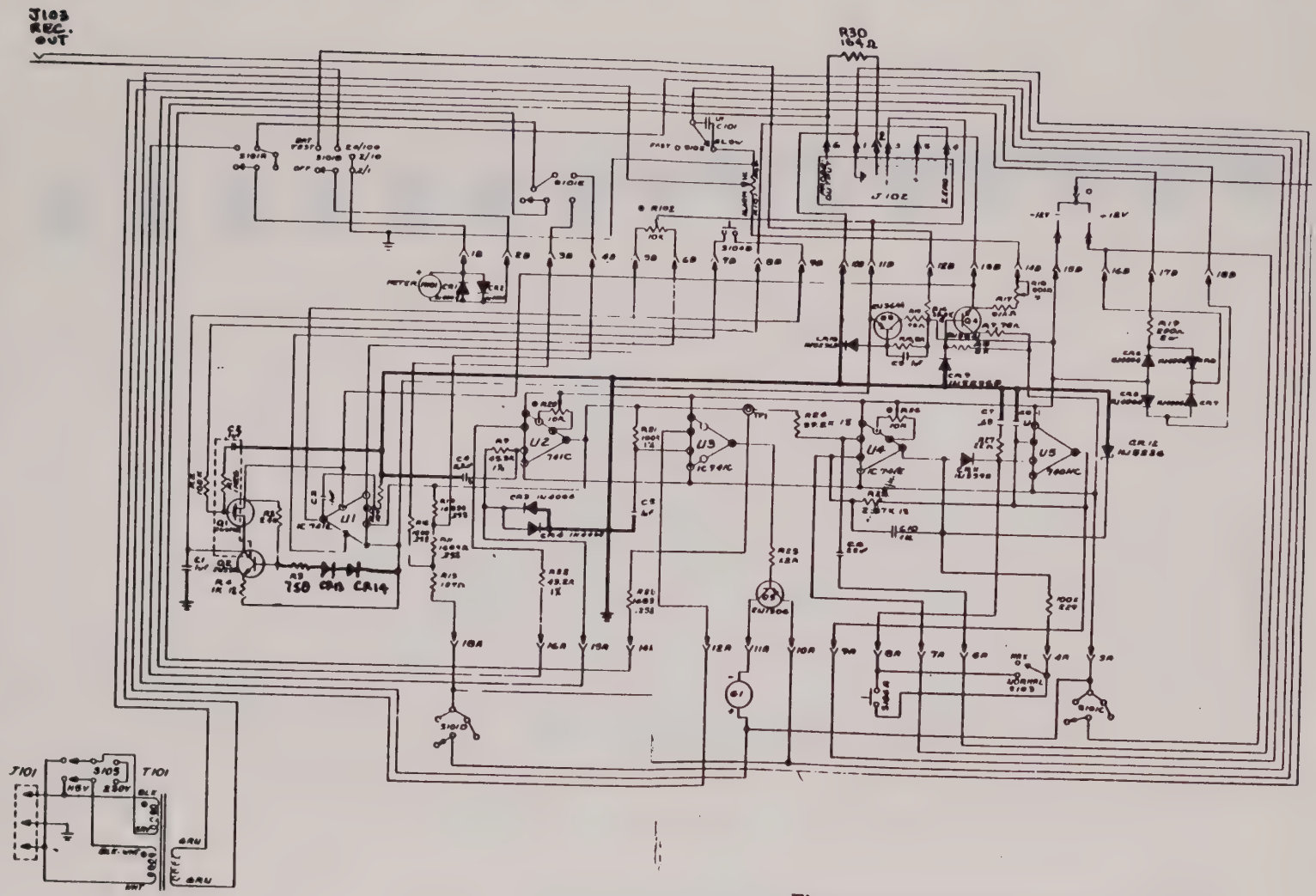


Figure 3-6. 8616 Radiation Monitor Schematic

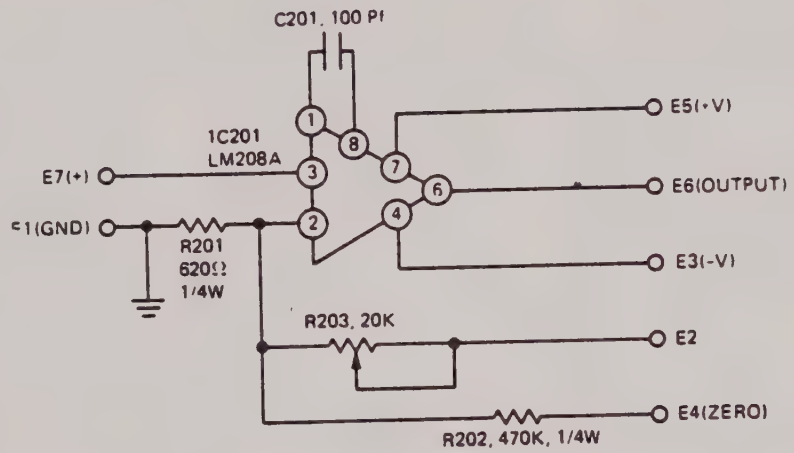
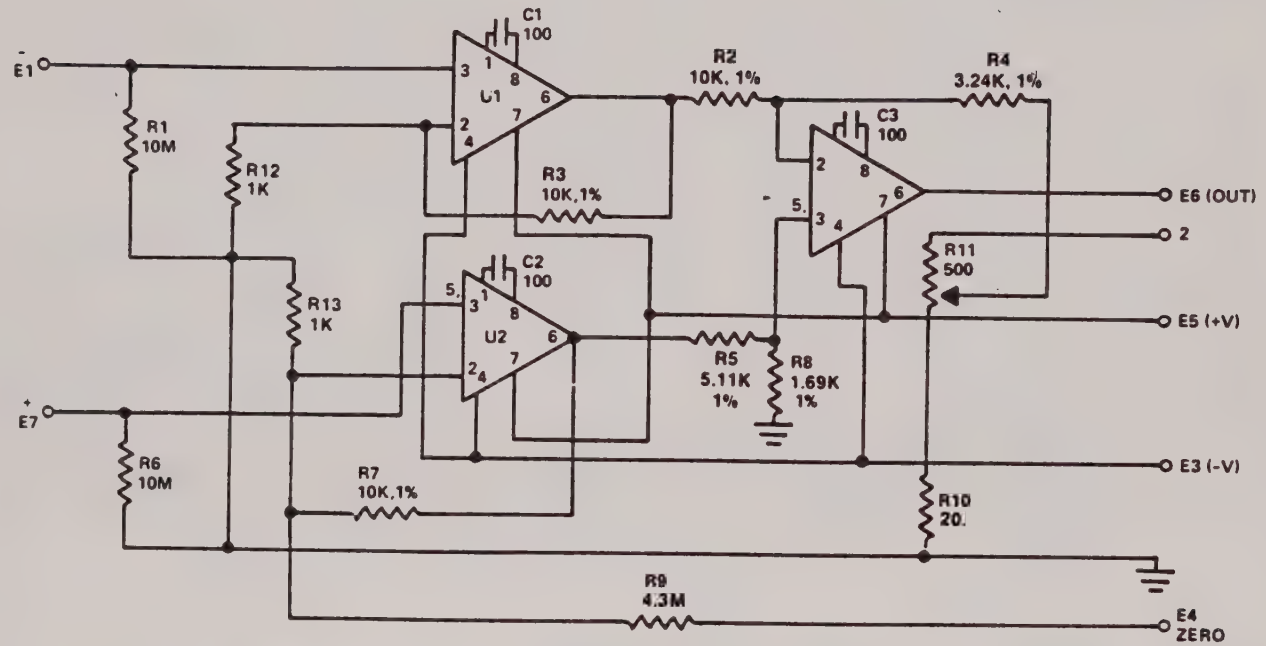


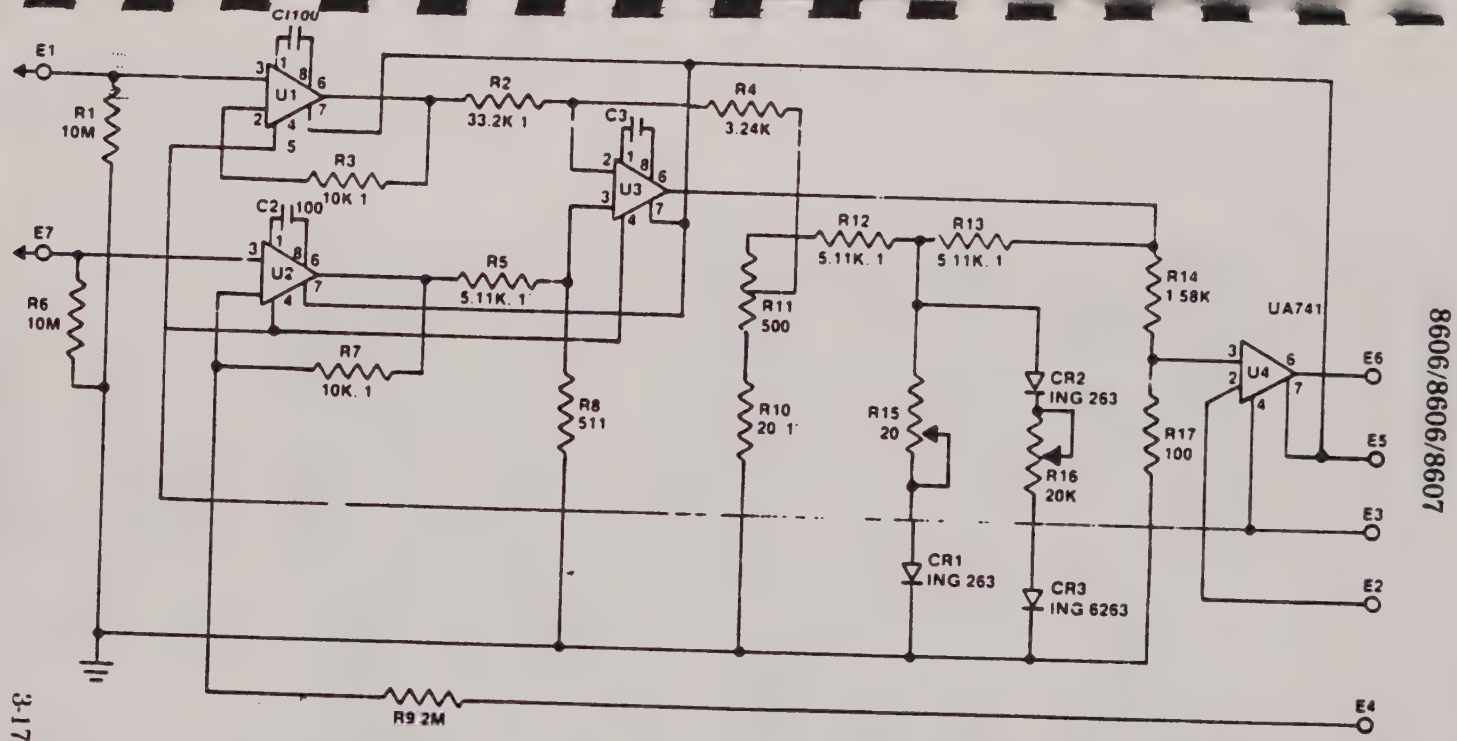
Figure 3-7. 8631/8633, 8621/8623 Probe Schematic

MODEL 8652 SCHEMATIC



NOTES - UNLESS OTHERWISE SPECIFIED:
1. RESISTOR VALUES ARE IN OHMS AND 1/8W, 5%.
2. CAPACITOR VALUES ARE pf AND 100V.

Figure 3-8. Schematic Probe 8652



NOTES: UNLESS OTHERWISE SPECIFIED
1) RESISTOR VALUES ARE IN OHM. ¼ WATT. 5%.
2) CAPACITOR VALUES ARE IN pf. 100V.

Figure 3-9. Schematic Probe 8662

SECTION IV

MAINTENANCE

4-1. GENERAL

4-2. This section provides information for calibration, maintenance and troubleshooting of Models 8606/8607/8608 RADIATION MONITORS. The Customer Service Department at Narda is available to provide re-calibration and maintenance service on these units. Inquiries should be addressed to:

Customer Service Department
The Narda Microwave Corporation
Hauppauge, New York 11788

4-3. REQUIRED TEST EQUIPMENT

4-4. The following test equipment is required for maintenance of the Model 8616 Radiation Monitor:

a.	Dual Regulated Power Supply	DL 40-1A
b.	Precision DC Voltmeter	Fluke Model 825A or Dana Model 4800
c.	V.O.M.	Simpson 260
d.	Potentiometer	10 KΩ, 1/2 W
e.	Resistor	5600Ω ±5%, 1/2 W
f.	Resistor	510Ω ±5%, 1/2 W

g.	Resistor	45,000Ω ±,1%, 1/2 W
h.	Resistor	4900Ω ±.1%, 1/2 W
i.	Resistor	100Ω ±.1%, 1/2 W
j.	Resistor	1000Ω ±5%, 1/2 W
k.	Connector	Amphenol 91-MC6M

4-5. METER ZERO

a. Set Model 8616 to OFF and mechanically zero the meter.

4-6. POWER SUPPLY TEST

NOTE

Probe should not be connected for this test.

a. Connect ± dual supply to battery terminals (battery disconnected). Power supply must have a range of ±13 to ±8.0 volts.

b. Jumper Pin 1 to Pin 6 of probe input connector.

c. Set selector switch to Battery Test and adjust ± supply voltage until meter reads at "Test Min". Power supply voltage must be between ±8 to ±9 volts.

4-7. Measure the positive voltage at pin 5 of the probe input connector and the negative voltage at pin 3.

a. These voltages must be between 6.3 and 7.2 volts.

b. Vary the dual supply voltage from "Test Min." to ±13 volts

c. Negative and positive voltages at pins 3 and 5 of the probe input connector must vary less than 0.1 volt.

4-8. ZERO OFFSET ADJUSTMENTS

a. Connect battery and set mode switch to NORMAL. Maintain the the supplied voltage unless otherwise specified.

b. Without a probe connected, short pin 6 of the probe input connector to pin 1.

c. Ground TP1 and adjust R26 for a zero meter indication.

d. Remove ground from TP1 and adjust R20 for a zero meter indication with range switch in most sensitive position (lowest power).

4-9. ZERO OFFSET

a. Connect Model 8623 Isotropic Probe to meter.

b. Set range switch to least sensitive range, and press zero pushbutton.

c. Set meter for zero indication by adjusting R102 while zero button is pressed.

d. Repeat step c for the other two ranges.

4-10. ALARM CALIBRATION

a. Disconnect probe and connect the test set-up shown in Figure 4-1. (Set switches to positions as shown.)

b. Set the range switch to low sensitivity (20/100 mW/cm^2) and zero the meter.

c. Set ALARM control to 100%.

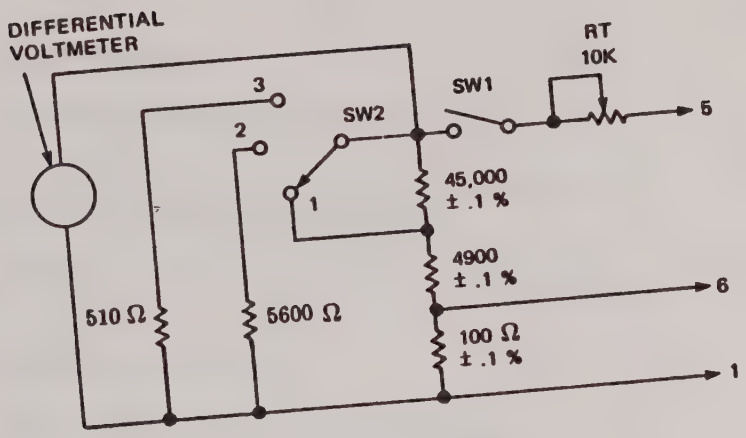


Figure 4-1. Test Set-Up

d. Close switch SW1 and adjust R_T for a full scale indication on the meter.

e. Adjust R18 for an alarm threshold.

f. Open switch SW1 and set R_T to maximum resistance.

g. Set ALARM control to 50% position.

h. Close SW1 and adjust R_T to alarm threshold. Note that meter reads between 45% and 55% of full scale.

4-11. METER RESPONSE

a. Set ALARM control to 100%.

b. Set R_T for 100% indication.

c. Open switch SW1.

d. Set METER RESPONSE switch to SLOW.

e. Close switch SW1 and time the period from switch closure to 90% of full scale meter indication.

f. This period must be less than 3 seconds. Reset switch to FAST position.

4-12. RANGE CALIBRATION

a. Set Model 8616 to high sensitivity position.

b. Open switch SW1 and set switch SW2 to position 3.

c. Check for zero meter indication.

d. Close switch SW1 and record the Differential Voltmeter (DVM) reading at an exact full scale monitor meter indication. DVM reading should be between .485 and .515 volts.

e. Set 8616 to next position.

f. Set switch SW2 to position 2 and adjust R1 for exact full scale indication on 8616 meter. DVM should read between 4.85 and 5.15 volts.

g. Set 8616 to lowest sensitivity position.

h. Set switch SW2 to position 1 and adjust R1 for exact full scale indication on the Model 8616. DVM should read between 4.85 and 5.15 volts.

4-13. RECORDER OUTPUT

a. At a full scale meter indication, note recorder output voltage to be 3 volts ±10% at minimum 1 K load.

4-14. BATTERY CHARGE CURRENT

a. Disconnect dual supply and connect battery to Model 8616. Set power switch off.

b. Connect ammeter in series with the positive battery terminal.

c. Set 115/230 VAC switch to "115" and connect charge cable to 115 volt, 60 Hz power source.

d. Charge current should be 40 to 50 ma as indicated on the ammeter.

e. Set 115/230 VAC switch to "230".

f. Connect charge cable to 230 VAC line.

g. Charge current should be 40 to 55 ma as indicated on the ammeter.

h. Disconnect charge cable and set switch to 115 volt position.

4-15. MAXIMUM HOLD OPERATION

a. Connect the test set up shown in Figure 4-1. Set switch SW1 to open and switch SW2 to position 1.

b. Set 8616 range switch to low sensitive position and Mode switch to "Max-Hold".

c. Press zero pushbutton.

d. Close switch SW1 and adjust R_T for a meter indication of 95% full scale.

e. Open switch SW1 and note that meter indication is maintained without drift. (Less than 2% in 5 minutes.)

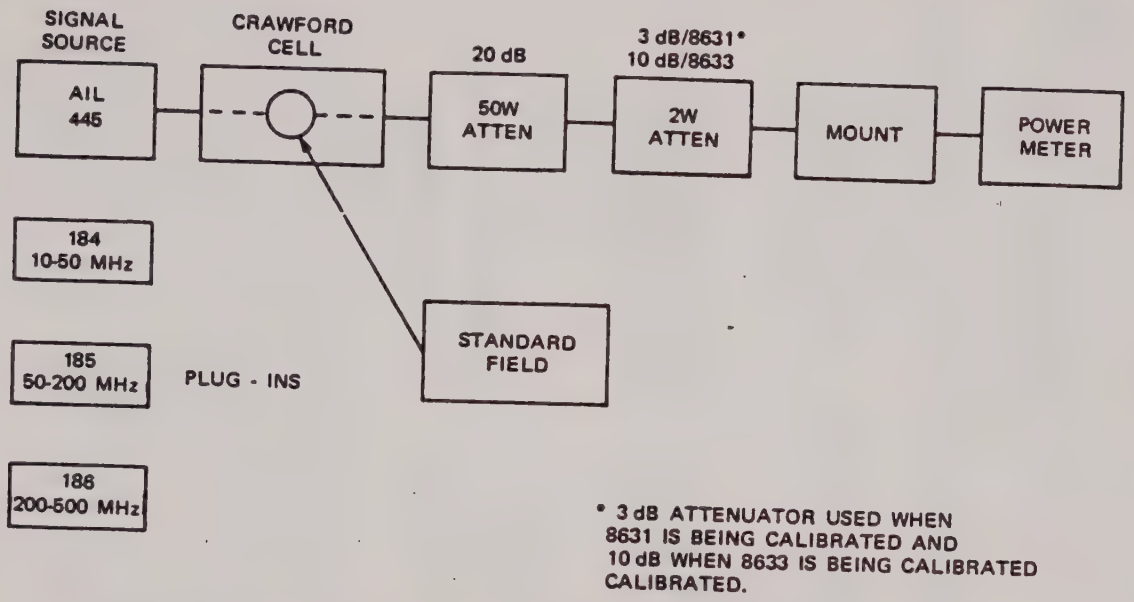


Figure 4-2. Low Frequency Probe Calibration Test Set-Up for 10 to 500 MHz

f. Press zero pushbutton and note that meter returns to zero.

4-16. REQUIRED TEST EQUIPMENT, MODELS 8631/8633

4-17. The following equipment is required to calibrate Models 8631 and 8633 Low Frequency Probes.

Signal Source 10 MHz to 300 MHz (min. 10 watts)	AIL Model 445 Plug-In Models 184 185 186
20 dB, 50 watt Attenuator	Narda 765-20
10 dB, 2 watt Attenuator	Narda 773-10
3 dB, 2 watt Attenuator	Narda 773-3
Power Meter	Narda 8440
Mount	Narda 8421
Crawford Cell (TEM)	Narda 8801
Radiation Monitor	Narda 8616

4-18. GENERAL

4-19. Probes should be tested at the following frequencies:

10 MHz	75	200
13	100	225
27	125	250
40	150	275
50	175	300 MHz

NOTE

The recommended test chamber for these calibration procedures is Narda's Model 8801 TEM Cell. The TEM Cell has the required 15 cm spacing between the Septum and the upper cell wall. An equivalent test chamber is described in the November 1974 edition of "IEEE Transactions on Electromagnetic Compatibility".

4-20. POWER REQUIREMENTS

a. Model 8631 Probes must be calibrated in a field of 1 mW/cm^2. This corresponds to a transmitted power of 1.69 watts in a 15 cm septum to wall spacing.

b. Model 8633 Probes must be calibrated in a field of 5 mW/cm^2. This corresponds to a transmitted power of 8.46 watts for the 15 cm septum to wall spacing.

c. See Figure 4-2 for test setup.

4-21. INITIAL CALIBRATION PROCEDURE (27 MHz)

a. Establish appropriate field at 27 MHz using Narda Model 8801 TEM Cell or equivalent.

b. Insert probe in test chamber with sphere approximately centered within the septum and midway between the septum and the broad wall.

c. Rotate the probe through maximum and minimum and note average point of any polarization ellipse.

d. Set calibration potentiometer for an approximate mid-scale reading at 27 MHz. Record the resistance value between Pins 1 and 2 of probe connector. (The procedure to access the calibration potentiometer is outlined in paragraph 4-23.)

e. Note that the ellipse ratio max/min is less than 1.26.

4-22. FREQUENCY CALIBRATION

a. Record the reading at the avarage of the ellipse for all test frequencies. These readings shall be recorded as "G".

b. Determine "M" equal to:

For 8631 $$M = \sqrt{\frac{1}{(G1L \times G1H)}}$$

For 8633 $$M = \sqrt{\frac{5}{(G1L \times G1H)}}$$

Where G1L is the lowest reading and G1H is the highest reading over frequency range of 13 MHz to 200 MHz.

NOTE

For Model 8633, if white scale (0-2) is recorded for G1 then,

$$M = \sqrt{\frac{1}{(G1L \times G1H)}}$$

c. Multiply all G1 readings by M to obtain G2. Record all G2 readings.

d. Multiply the recorded value of resistance (paragraph 4-21, step d) by M. Reset the calibration potentiometer to the resultant value.

4-23. CALIBRATION POTENTIOMETER ACCESS PROCEDURE

a. See Figure 4-3.

b. Remove Phillips head screw at front of probe handle. (A)

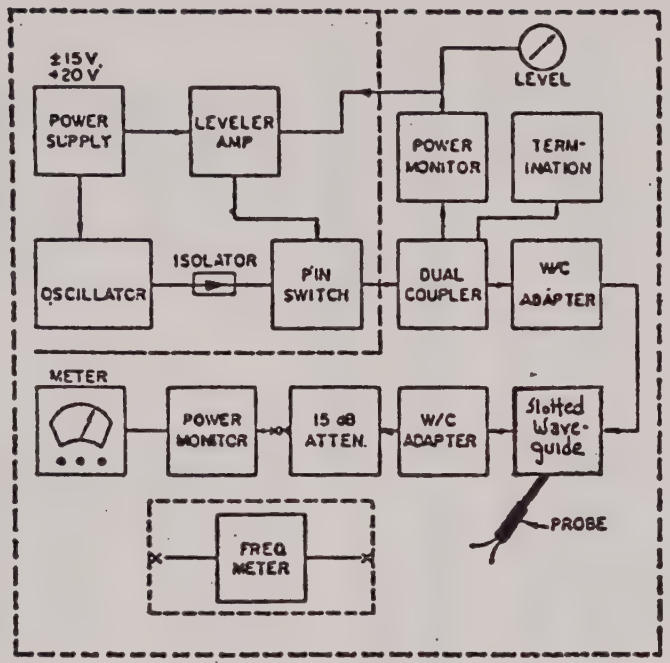


Figure 4-3. Calibration Test Set-Up for 500 MHz to 1.1 GHz

c. Remove set screw (B) from handle.

d. Rotate the handle (C) counter clockwise until set screw hole (B) lines up with potentiometer adjustment slot.

CAUTION

Do not rotate handle greater than one complete turn.

e. After adjustment, reverse procedure by rotating handle clockwise until phillips head screw can be placed in hole (A).

f. Re-insert set screw (B) and rotate until flush with handle case.

4-24. REQUIRED TEST EQUIPMENT, MODELS 8621/8623

4-25. The following equipment is required to calibrate Models 8621 and 8623 High Frequency Probes.

a.	Signal Source	Narda 9535
b.	Signal Source	AIL Model 445
c.	500 - 1000 MHz Plug - In	AIL Model 187
d.	TWT Amplifier	Servo Model S979
e.	TWT Amplifier	Servo Model C979
f.	TWT Amplifier	Servo Model H979
g.	TWT Amplifier	Keltec Model KUR607-10
h.	Isolator	Sperry Model D44515

i.	Isolator	Addington Model 217-0600
j.	Isolator	Sperry Model D44X15
k.	Isolator	Sperry Model D44L15
l.	Isolator	E and M Labs Model KU915LJ
m.	Low Pass Filter	HP Model 360D
n.	Dual Directional Coupler	Narda Model 3022
o.	Dual Directional Coupler	Narda Model 3024
p.	Waveguide Directional Coupler	Narda Model 1080
q.	Dual Directional Coupler	Narda Model 3020A
r.	Waveguide Directional Coupler	Narda Model 1079
s.	Attenuators 20 dB (2 required)	Narda Model 779-20
t.	Attenuator 10 dB	Narda Model 779-10
u.	Power Meters (2 required) with 2 mounts	Narda Model 8400 with Model 8421 Mount
v.	Power Meter	HP 432
w.	Thermistor Mount	HP P486A

x.	Waveguide to Coaxial Adapter	Narda Model 613A
y.	Waveguide to Coaxial Adapter	Narda Model 614A
z.	Waveguide to Coaxial Adapter	Narda Model 615
aa.	Waveguide to Coaxial Adapter	Narda Model 612A
ab.	Waveguide to Coaxial Adapter	Narda Model 601A
ac.	Standard Gain Horn	Narda Model 644
ad.	Standard Gain Horn	Narda Model 643
ae.	Standard Gain Horn	Narda Model 645
af.	Standard Gain Horn	Narda Model 642
ag.	Standard Gain Horn	Narda Model 640
ah.	Standard Gain Horn	S. A. 12-0-75
ai.	Standard Gain Horn	Narda Model 646
aj.	Standard Gain Horn	Narda Model 639
ak.	Standard Gain Horn	Narda Model 638
al.	Directional Coupler	Narda Model 1068-10
am.	Thermistor Mount	H.P. Model K486A

an.	Isolator	P&H Labs Model A3-K15210
ao.	Signal Source	HP 8690+8696A
ap.	Anechoic Chamber	

4-26. HIGH FREQUENCY PROBE CALIBRATION, MODELS 8621/8623

4-27. An anechoic sled should be used when establishing a standard field for calibration. This will permit the averaging of multipath interference.

4-28. Because probe calibrations are made at relatively close distances, it is necessary to use the near zone gain of the horns for the separation distances used. Table 4-2 shows the transmitted power (Pt) required for specific frequencies at noted separation distances using standard gain horns. This table should be used in conjunction with the test set-ups illustrated in Figures 4-5 through 4-9. Transmitted powers are based upon the near zone connected gain horn.

$$Pt = \frac{Pa\ R^2\ 4\pi}{G}$$

Where:
Pt = Transmitted Power
R = Separation Distances
Pa = Power Densities
G = Near zone, Horn gain, numerical

Table 4-1. Transmitted Power Requirements

Frequency	Horn, Narda Model	Separation Distance (cm)	Power Density	Transmitted Power (Pt Watts)
1700	645	100	1 mw/cm^2	5
2450	645	200	1 mw/cm^2	9.89
4000	643	100	1 mw/cm^2	4.07
5000	643	100	1 mw/cm^2	2.98
6000	642	100	1 mw/cm^2	3.74
7000	642	100	1 mw/cm^2	2.81
8200	640	100	1 mw/cm^2	4.40
9300	640	100	1 mw/cm^2	3.62
10,000	640	100	1 mw/cm^2	3.15
11,000	640	100	1 mw/cm^2	2.59
18,000	639	50	0.1 mw/cm^2	.0574
26,000	638	25	0.1 mw/cm^2	.0129

For power density of 5 mw/cm^2, Transmitted Power is 5 times that indicated above for 1 mw/cm^2.

4-29. Record the resistance between pins 1 and 2 of the probe connector.

4-30. Using the appropriate test setup for the test frequencies listed in Table 4-1, obtain a power density of 1 mw/cm^2 at the center plane of the 8621 sphere. The probe axis is to be aligned with the 1 Poynting rector (direction of propagation). The probe should be rotated about its axis to the position of the average of any polarization ellipse.

4-31. For Model 8623 probes, establish a power density of 5 mw/cm^2 for a standard calibration field.

4-32. FREQUENCY ALIGNMENT

a. Record the readings at the average of the ellipse for all test frequencies. These readings shall be recorded as "G".

b. Determine "M" equal to:

for 8621 $$M = \frac{1}{\sqrt{(G_{iL} \times G_{iH})}}$$

for 8623 $$M = \frac{5}{\sqrt{(G_{iL} \times G_{iH})}}$$

G_{iL} is the lowest reading and G_{iH} is the highest reading over the range of 1700 MHz to 11 GHz.

c. Multiply all G_1 readings by M to obtain G_2. Record all G_2 readings.

d. Reset the resistance from Pin 1 to Pin 2 of probe connector to M times the value recorded in paragraph 4-29. For access to the calibration potentiometer, refer to paragraph 4-23.

4-33. TROUBLE SHOOTING

4-34. Table 4-2 provides a troubleshooting chart for the Models 8606/8607/8608 Radiation Monitors. Trouble symptoms are based on the performance test paragraphs of this section. Reference should be made to the schematic diagram.

4-35. BATTERY CHARGING

4-36. If meter reads below Test Min. , connect charging line cord and recharge battery. Use to charge ratio is 2.5:1. Every 1 hour of charge time will allow 2.5 hours of use. A fully charged battery will permit a minimum of

40 hours of use time. Sixteen hours of charge time will insure a fully charged battery. Model 8616 may be charged indefinitely without any danger of damage to either the battery or meter.

NOTE

The required charging power source voltage is indicated at the front panel line cord connector. It will indicate 115 or 230. This must correspond to the line source voltage. An internal charging switch may be reset to accomodate the available source.

4-37. BATTERY REPLACEMENT

a. Remove mounting screws at rear of case and remove unit from case.

b. Remove two screws at bottom of front panel that secure battery bracket to unit.

c. Disconnect three battery snaps and note connections to allow correct replacement.

d. Remove two screws which secure battery straps to battery bracket and remove battery straps and battery.

e. Install new battery and secure to battery bracket with strap and screws removed in step d. Insure that battery does not slide or shift position and that battery contacts do not touch battery bracket.

f. Reconnect three battery snaps as noted in step c.

g. Reassemble battery bracket to front panel and cover onto unit with new screws. Be sure that finger seals are properly seated on all four cover edges and that all screws are tightened securely.

Table 4-2. Troubleshooting Chart

Symptom	Probable Cause	Remedy
Battery Test fails	Undercharged battery	Charge battery, refer to paragraph 4-35
Battery doesn't charge	a. Defective battery	a. Perform Charge Current Test, refer to paragraph 4-14. NOTE If test passed, replace battery, refer to paragraph 4-37.
	b. Defective Charging Cable	b. Replace Charging Cable.
	c. Defective charging circuit	c. Check CR5 through CR8, R19 and T101. Replace faulty component. Refer to paragraph 4-38.

Table 4-2 (Cont)

Meter can not be zeroed	Defective thermo-couple in probe.	Replace probe.
Alarm sounds with probe connected. (no rf power)	a. Defective thermo-couple in probe.	a. Replace probe.
	b. Unit not properly zeroed	b. Zero unit, refer to paragraph 4-9.
Recorder output test fails or range calibration test fails.	Faulty amplifier stage	Determine faulty stage and replace defective component refer to paragraph 4-38.
Charge current test fails	a. Faulty charge cable	a. Replace charge cable.
	b. Faulty diodes CR5, CR6, CR7, CR8 or R19.	b. Replace faulty diodes, refer to paragraph 4-38.
Electromagnetic compatibility test	a. Cover screws not securely tightened.	a. Replace screws and tighten.

Table 4-2 (Cont)

b. Meter cover improperly assembled or gasket worn or missing.	b. Reassemble meter, cover and replace gasket refer to paragraph 4-39.
c. Finger seals missing or improperly assembled cover.	c. Replace finger seals or reassemble properly.

4-38. PRINTED CIRCUIT BOARD COMPONENTS AND FRONT PANEL REPLACEMENT

a. Remove cover from unit by removing six screws.

b. Remove two screws at bottom of front panel which secure battery bracket to unit. Remove battery bracket.

c. Disconnect three battery snaps from battery terminals.

NOTE

At this point, printed circuit board components are all accessible. Continue with steps d through f to gain access to the rear of the printed circuit board as well as the front panel components.

d. Remove two meter nuts which secure printed circuit board at the top.

e. Remove the PC board screw, lock, and flat washers which secure PC board at the bottom.

f. Pull out connectors at both sides of PC board and remove PC board.

NOTE

Rear of PC board and rear of front panel are now accessible. Components may be removed using standard procedures (except for meter).

g. To reassemble unit, reverse the above procedures. When connecting the three wires, make sure that they are properly connected.

4-39. METER REPLACEMENT

a. Perform steps a through f of paragraph 4-38.

b. Remove nuts and four washers securing meter cover and remove meter cover with gasket.

c. Remove No. 6 nuts which secure meter to front panel and remove meter.

d. To reassemble, insert meter through front panel and secure with No. 6 nuts.

e. Place gasket around meter.

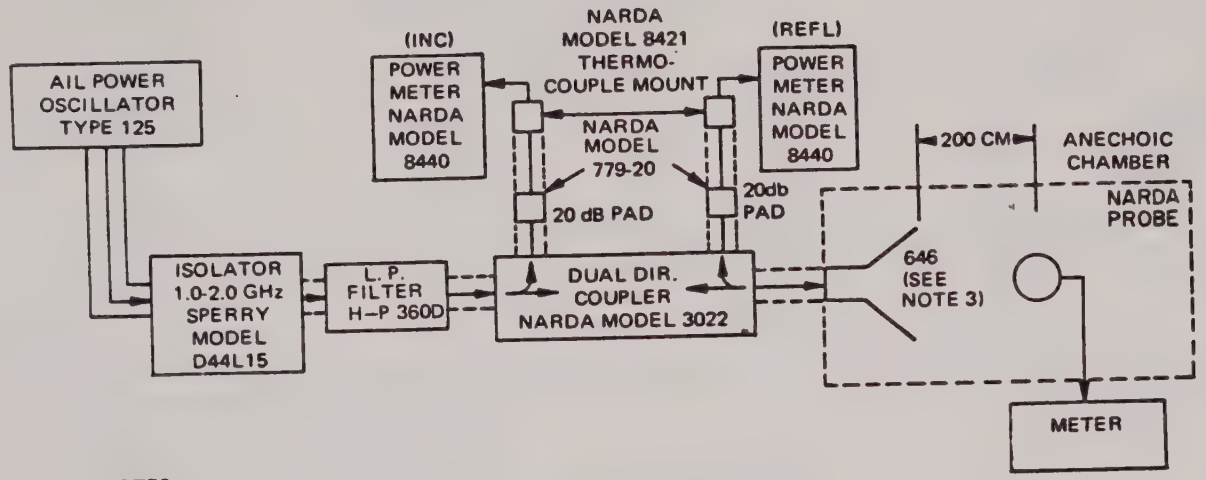
f. Place two thin anodized washers on the meter studs.

g. Place cover over meter making sure gasket is properly seated and that meter studs do not contact meter cover.

h. Secure meter cover with thick anodized washer and nut.

i. Check with an ohmmeter to insure that meter cover is not shorted to ground.

j. Perform step g of paragraph 4-38.



NOTES:

1. ═══ RG-9B/U CABLE CONNECTION
2. ═ ═ ═ ═ DIRECT COAXIAL CONNECTION
3. WHEN MAKING CALIBRATION FROM 1.7 TO 2.6 GHz, USE MODEL 645.

Figure 4-4. Calibration Test Set-Up for 1.1 to 2.6 GHz Frequency Range

8608/8606/8607

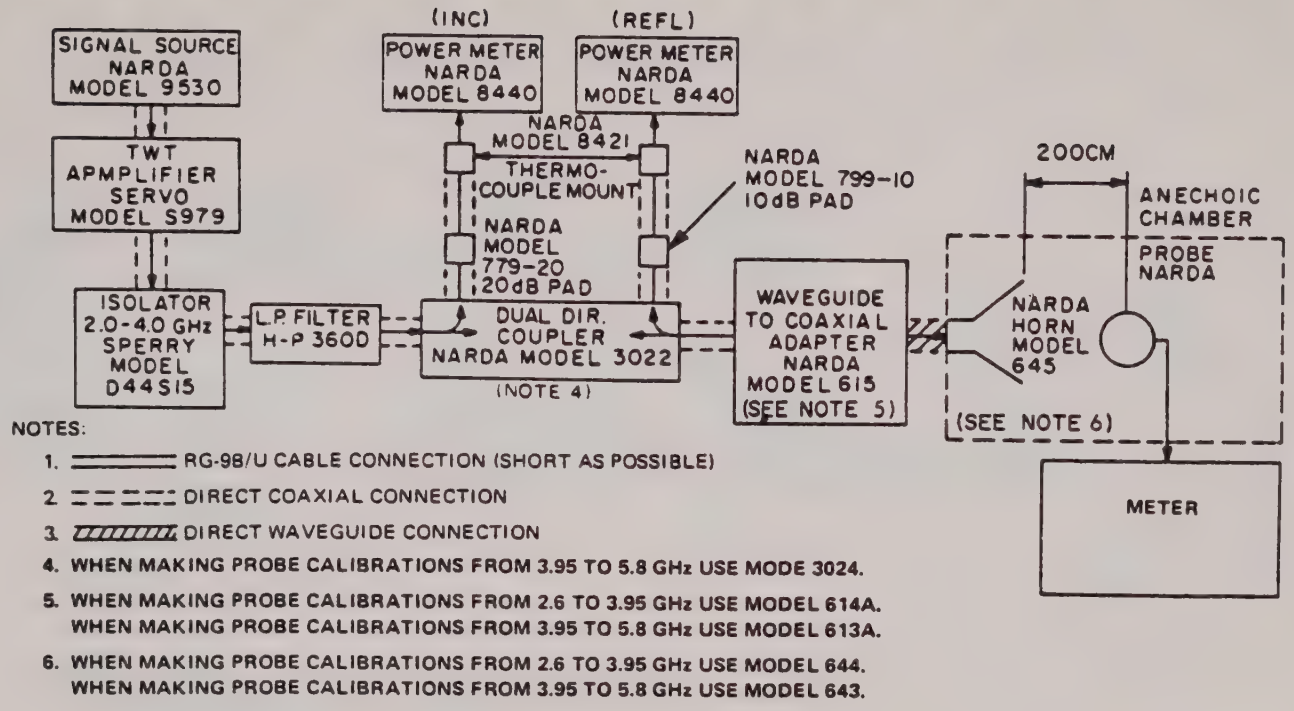
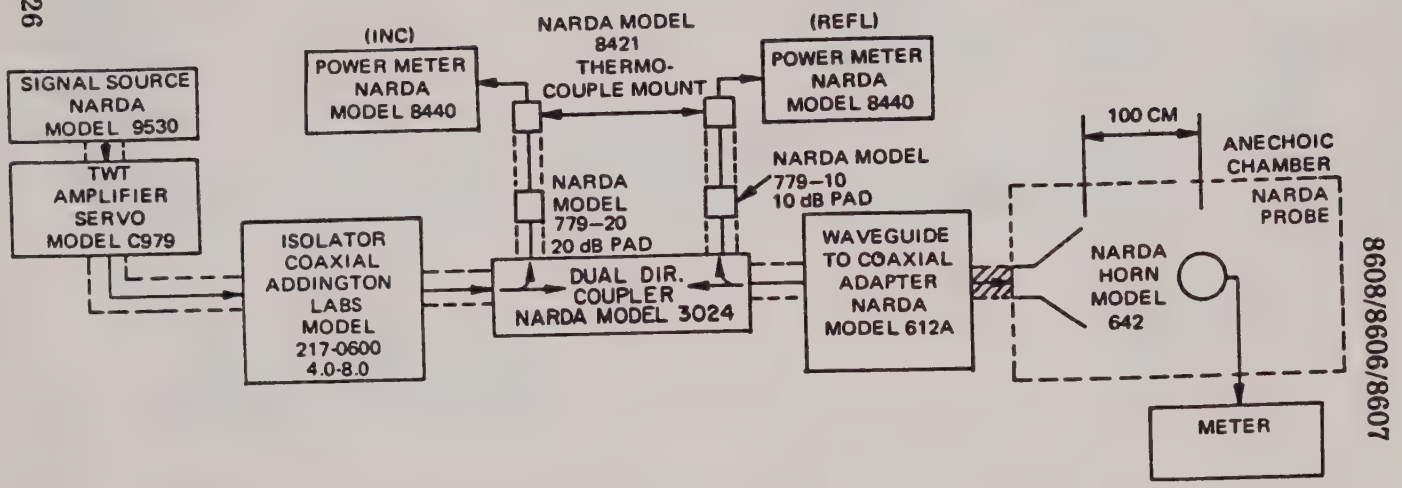

(INC)
(REFL)
SIGNAL SOURCE NARDA MODEL 9530
POWER METER NARDA MODEL 8440
POWER METER NARDA MODEL 8440
NARDA MODEL 8421
THERMO-COUPLE MOUNT
NARDA MODEL 779-10 10dB PAD
200CM
ANECHOIC CHAMBER
PROBE NARDA
TWT APMPLIFIER SERVO MODEL S979
NARDA MODEL 779-20 20dB PAD
ISOLATOR 2.0-4.0 GHz SPERRY MODEL D44S15
L.P. FILTER H-P 3600
DUAL DIR. COUPLER NARDA MODEL 3022
(NOTE 4)
WAVEGUIDE TO COAXIAL ADAPTER NARDA MODEL 615 (SEE NOTE 5)
NARDA HORN MODEL 645
(SEE NOTE 6)
METER
8608/8606/8607
NOTES:
1. RG-98/U CABLE CONNECTION (SHORT AS POSSIBLE)
2. DIRECT COAXIAL CONNECTION
3. DIRECT WAVEGUIDE CONNECTION
4. WHEN MAKING PROBE CALIBRATIONS FROM 3.95 TO 5.8 GHz USE MODE 3024.
5. WHEN MAKING PROBE CALIBRATIONS FROM 2.6 TO 3.95 GHz USE MODEL 614A.
WHEN MAKING PROBE CALIBRATIONS FROM 3.95 TO 5.8 GHz USE MODEL 613A.
6. WHEN MAKING PROBE CALIBRATIONS FROM 2.6 TO 3.95 GHz USE MODEL 644.
WHEN MAKING PROBE CALIBRATIONS FROM 3.95 TO 5.8 GHz USE MODEL 643.

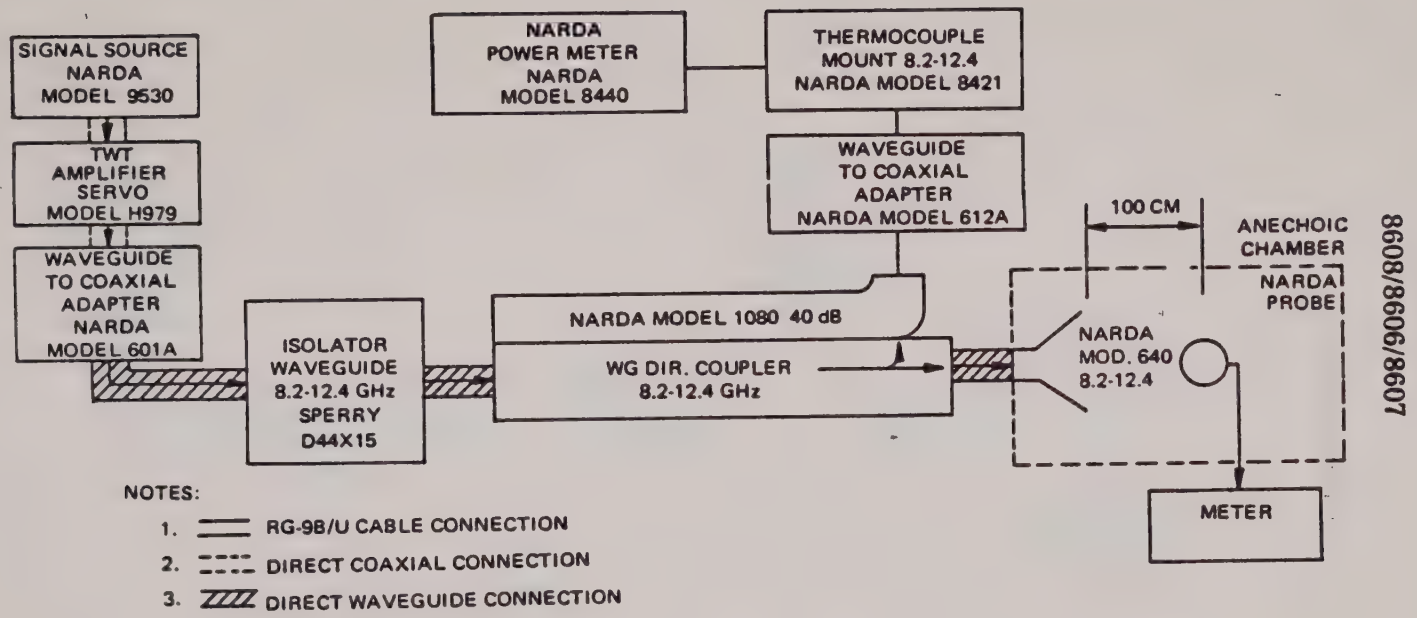
Figure 4-5. Electromagnetic Test Set-Up for 1.7 to 5.8 GHz



NOTES:

1. RG-9B/U CABLE CONNECTION (SHORT AS POSSIBLE)
2. DIRECT COAXIAL CONNECTION
3. DIRECT WAVEGUIDE CONNECTION

Figure 4-6. Calibraiton Test Set-Up for 5.4 to 8.2 GHz Frequency Range



8608/8606/8607

Figure 4-7. Calibration Test Set-Up for 8.2 to 12.4 GHz Frequency Range

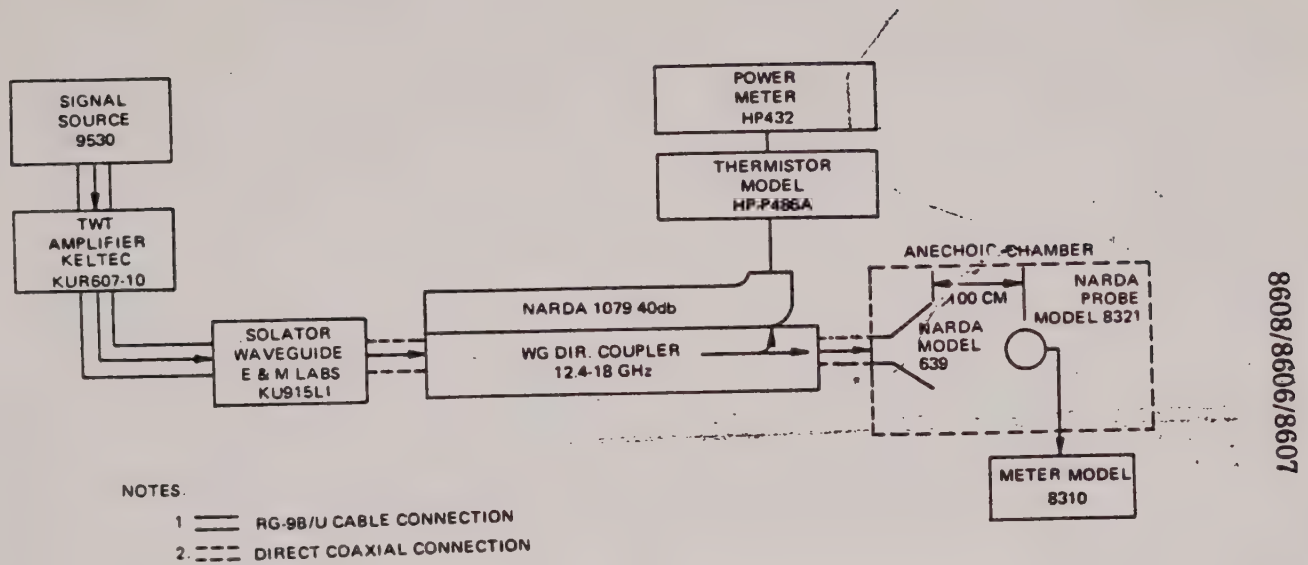


Figure 4-8. Calibration Test Set-Up for 12.4 to 18.0 GHz Frequency Range

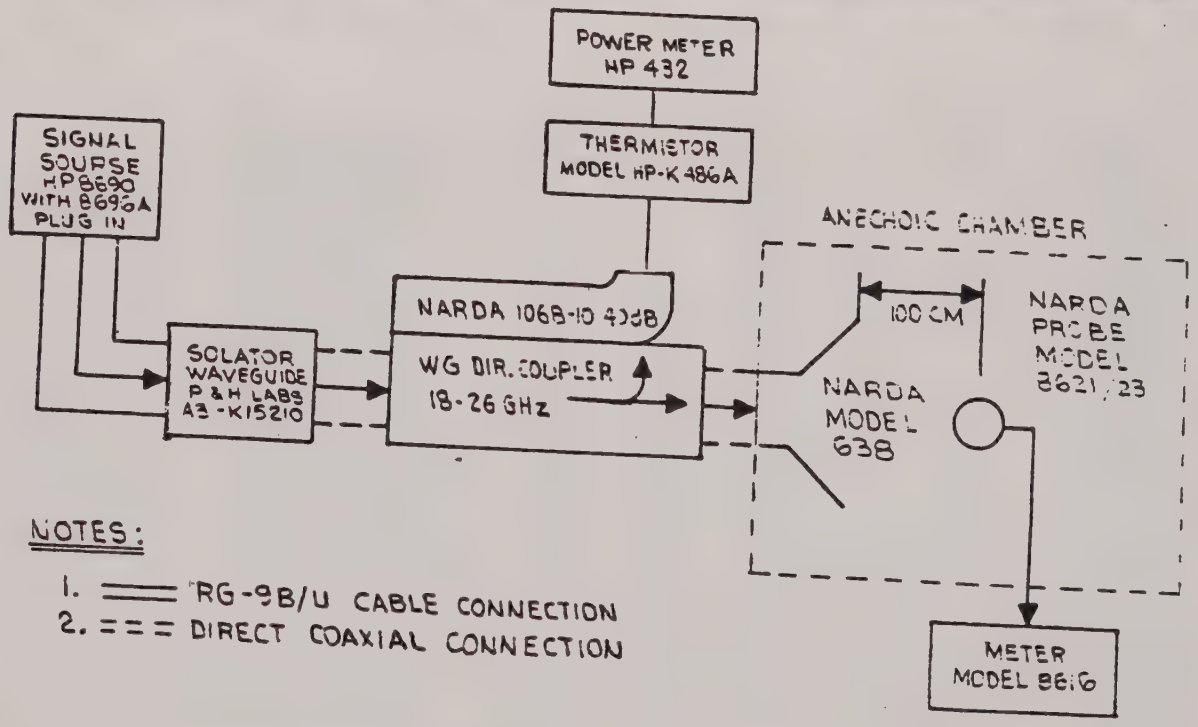


Figure 4-9. Calibration Test Set-Up for 18 to 26 GHz Frequency Range

SECTION V

REPLACEMENT PARTS LIST

5-1. GENERAL

5-2. This section provides a complete listing of the replaceable parts of this unit. The listing contains the necessary ordering information. Parts are listed in alpha-numerical order by reference designator. Complete descriptions of each component are provided in addition to the manufacturer's code and Narda part number in order to facilitate ordering of replacement parts. (See Tables 5-1 and 5-2.)

5-3. ORDERING INFORMATION

5-4. If it is desired to order replacement parts from the instrument manufacturer, address the order to:

SALES DEPARTMENT
The Narda Microwave Corporation
Hauppauge, New York 11788

5-5. When ordering a part in this manner, the following information should be provided:

a. Model and serial number of the instrument.

b. Narda part number.

c. Reference designation.

d. Description.

5-6. When ordering components or parts not listed in table 5-2, a complete description of the part, including its function and location should be provided with the model and serial number of the instrument.

5-7. CUSTOMER REPAIR SERVICE

5-8. Repairs or recalibration of Narda Products are performed by the Customer Service Department at the factory; however, before returning any unit, contact the Narda Microwave Corporation or the local Narda Sales Representative in your area for shipping instructions.

Table 5-1. Manufacturer's Code

Manufacturer's Supply Code	Name	Address
01121	Allen Bradley Co.	Milwaukee, WI
01295	Texas Instruments, Inc.	Dallas, TX
02660	Amphenol	Broadview, IL
04713	Motorola Semiconductor	Phoenix, AZ
05245	Corcom	Chicago, IL
05397	Kemet Div. of Union Carbide	New York, NY
07263	Fairchild Camera and Instrument Corp.	Mountain View, CA
12697	Clarostat Mfg. Co., Inc.	Dover, NH

Table 5-1 (Cont)

16299	Corning Class Works	Raleigh, NC
28480	Hewlett Packard	Palo Alto, CA
30983	Electra/Midland	San Diego, CA
56289	Sprague	North Adams, MA
72982	Erie Technological Products, Inc.	Erie, PA
73445	Amperex,	Hauppauge, NY
80294	Bourns, Inc.	Riverside, CA
82349	Switchcraft, Inc.	Chicago, IL
95146	Alco Electronic Products	Lawrence, MA
95275	Vitramon, Inc.	Bridgeport, CT
99899	Narda Microwave Corp.	Plainview, NY

Table 5-2. Replaceable Parts List

Ref. Des.	Description	Mfg. Code	Manufacturer's Part Number	Narda Part No.
B1	Battery	99899		88011000
C1	Capacitor, 1 uf, 50 WVDC	56289	5C13	80139105
C2	Capacitor, .1 uf, 100 WVDC	73445	C281CH/A100K	80195000
C3	Capacitor, .1 uf, 50 WVDC	95275	CR05	80187005
C4	Capacitor, 2.2 uf, 35 WVDC	05397	T360A225MO20AS	80198004
C5	Capacitor, 1 uf, 50 WVDC	56289	5C13	80139105
C6	Capacitor, 22 uf, 15 WVDC	05397	T360B226MO15AS	80198003
C7	Capacitor, .68 uf, 100 WVDC	73445	C280MCH/A680K	80221000

Table 5-2 (Cont)

C8	Capacitor, .1 uf, 25 WVDC	72982	5815-000Y50104Z	80123009
C9	Capacitor, 1 uf, 50 WVDC	56289	5C13	80139105
CR1	Diode	01295	IN4004	84568004
CR2	Diode	01295	IN4004	84568004
CR3	Diode	01295	IN4004	84568004
CR4	Diode	01295	IN4004	84568004
CR5	Diode	01295	IN4004	84568004
CR6	Diode	01295	IN4004	84568004
CR7	Diode	01295	IN4004	84568004
CR8	Diode	01295	IN4004	84568004
CR9	Diode	04713	5236B	84591000
CR10	Diode	04713	5236B	84591000
CR11	Diode	04713	IN3595	84704000
CR12	Diode	04713	IN5226	84729000
G1	Son. Alert Assy.	99899		306934
J101	Power Line Filter	05245	1B4	81659000
J102	Connector Assy.	02660	91-PC6F	81523041
J103	Recorder Assy.	99899		306948

Table 5-2 (Cont)

M101	Meter	99899		315173
Q1	Transistor	04713	2N3796	89018097
Q2	Transistor	07263	2N3568	89018006
Q3	Transistor	07263	2N3644	89018010
Q4	Transistor	07263	2N3641	89018009
Q5	Transistor	02735	2N1306	89018026
R1	Resistor, Fixed Comp. 1M, 1/4W, 5%	01121	RCO7GF105T	83015121
R2	Resistor, Fixed Comp. 100K, 1/4W, 5%	01121	RCO7GF104T	83015097
R3	Resistor, Fixed Comp. 24K	01121	RCO7GF243T	83015082
R4	Resistor, Metal Oxide 1K, 1/8W, 1%	07716	CEA-TO	83049192
R5	Resistor, Fixed Comp. 4.3K, 1/4W, 5%	01121	RCO7GF432T	83015040
R6	Resistor, Metal Oxide 10K, 1/8W, 1%	07716	CEA-TO	83049288

Table 5-2 (Cont)

R7	Resistor, Fixed Comp. 75Ω, 1/4W, 5%	01121	RCO7GF750T	83015022
R8	Resistor, Fixed Comp. 2K, 1/4W, 5%	01121	RCO7GF202T	83015056
R9	Resistor, Metal Oxide 45.3K, 1/8W, 1%	07716	CEA-TO	83049350
R10	Resistor, Metal Oxide 16.83K, 1/8W, 1/4%	16299	NA55D/RN55D	83170012
R11	Resistor, Metal Oxide 1683Ω, 1/8W, 1/4%	16299	NA55D/RN55D	83170011
R12	Resistor, Metal Oxide 1500Ω, 1/8W, 1/4%	16299	NA55D/RN55D	83170010
R13	Resistor, Metal Oxide 187Ω, 1/8W, 1/4%	16299	NA55D/RN55D	83170009
R14	Resistor, Fixed Comp. 2K, 1/4W, 5%	01121	RCO7GF202T	83015056
R15	Resistor, Fixed Comp. 75Ω, 1/4W, 5%	01121	RCO7GF750T	83015022
R16	Resistor, Metal Oxide 28.0K, 1/8W, 1%	07716	CEA-TO	83049330
R17	Resistor, Fixed Comp. 51K, 1/4W, 5%	01121	RCO7FG513T	83015090
R18	Resistor, Var. 50K, 1W, 10%	30983	ET34P503-023	83128012

Table 5-2 (Cont)

R19	Resistor, Fixed Comp. 200Ω, 2W, 5%	01121	RC42GF201J	83011032
R20	Resistor Var. 10K, 1W, 10%	30983	ET34P103-023	83128010
R21	Resistor, Fixed Comp. 100K, 1/8W, 1%	07716	CEA-TO	83049383
R22	Resistor, Fixed Comp. 43.2K, 1/8W, 1%	07716	CEA-TO	83049348
R23	Resistor, Metal Oxide 1683, 1/8W, 1/4%	16299	NA55D/RN55D	83170011
R24	Resistor, Metal Oxide 39.2K, 1/8W, 1%	07716	CEA-TO	83049344
R25	Resistor, Fixed Comp. 1.2K, 1/4W, 5%	01121	RCO7GF122	83015051
R26	Resistor, Var. 10K, 1W, 10%	30983	ET34P103-023	83128010
R27	Resistor, Fixed Comp. 22Ω, 1/8W, 5%	01121	RCO7FG220T	83015009
R28	Resistor, Metal Oxide 2.87K, 1/8W, 1%	07716	CEA-TO	83049236
R101	Resistor, Var. 1000Ω, 2W, 10%	12697	43	83123018
R102	Resistor, Var. 10K	80294	3059J-1-103M	83161004

Table 5-2 (Cont)

S101	Switch, Rotary	99899		83709000
S102	Switch, SPDT	95146	MST-105D	83530000
S103	Switch, SPDT	95146	MST-105D	83530000
S104	Switch, DPDT Push-Button	95146	MSP-105R	83702000
S105	Switch, Slide 115-230	82349	46206LF	83509001
T101	Transformer	99899		84035000
U1	Integrated Circuit	07263	471E	84727000
U2	Integrated Circuit	07263	741E	84727000
U3	Integrated Circuit	07263	741C	84548000
U4	Integrated Circuit	07263	741C	84548000
U5	Integrated Circuit	07263	740HC	84705000
		Models 8621, 8623, 8631, 8633		
C201	Capacitor, 100 pf, 500 WVDC	72136	DM15E101J0500 WV4CR	80115027

Table 5-2 (Cont)

R201	Resistor, Fixed Comp. 620, 1/4W, 5%	01121	RC07GF621T	83015044
R202	Resistor, Fixed Comp. 470K, 1/4W, 5%	01121	RCO7GF474T	83015113
R203	Resistor, Variable 20K	80294	3292P-1-203	83195010
U101	Integrated Circuit	07263	LM208A	84728000
		Model 8662 Probe		
R1	Resistor, Fixed Comp. 10M 1/8W 5%	01121	RCO5GF106T	83164159
R2	Resister Metal Oxide 33.2K 1/8W 1%	07716	CEA-TO	83049337
R3	Resistor Metal Oxide 10K 1/8W 1%			83049288
R4	Resistor Metal Oxide 3.24K 1/8W 1%	07716	CEA-TO	83049241
R5	Resistor Metal Oxide 5.11K 1/8W 1%	07716	CEA-TO	83049260
R6	See R1			

Table 5-2 (Cont.)

R7	See R3			
R8	Resistor Metal Oxide 511, 1/8 W 1%	07716	CEA-TO	83049165
R9	Resistor Fixed Comp. 2M 1/8W 5%	01121	RC05GF205T	83164142
R10	Resistor, Metal Oxide 20, 1/8W	07716	CEA-TO	83049030
R11	Resistor, Variable 500	80294	3292P-1-501	83195005
R12	Resistor, Metal Oxide 5.11K 1/8W 1%	07716	CEA-TO	83049260
R13	See R12			
R14	Resistor Metal Oxide 1.58K 1/8W 1%	07716	CEA-TO	83049211
R15	Resistor Variable 20K	80294	3359W-1-203	83143000
R16	See R15			

Table 5-2 (Cont.)

R17	Resistor Metal Oxide 100 1/8 W 1%	07716	CEA-TO	83049097
C1	Capacitor, 100 pf	72136	DM15E101J0500 WV4CR	80115027
C2	See C1			
C3	See C1			
U1	Integrated Circuit	07263	LM208A	84728000
U2	See U1			
U3	See U1			
U4	Integrated Circuit	07263	μA741	84548000
CR1	Diode	28480	1N6203	84585004
CR2	See CR1			
CR3	See CR1			

R1	Resistor, Fixed Comp. 10M 1/8W 5%	01121	RC05GF106T	83164159
R2	Resistor Metal Oxide 10K 1/8W 1%	07716	CEA-TO	83049288
R3	See R2			
R4	Resistor Metal Oxide 3.24K 1/8W 1%	07716	CEA-TO	83049241
R5	Resistor Metal Oxide 5.11K 1/8W 1%	07716	CEA-TO	83049260
R6	See R1			
R7	See R2			
R8	Resistor Metal Oxide 1.69K 1/8W 1%	07716	CEA-TO	83049214
R9	Resistor Metal Oxide 4.3M 1/8W 5%	01121	RC05GF435T	83164150
R10	Resistor, Metal Oxide 20M 1/8W 1%	07716	CEA-TO	83049030

Table 5-2 (Cont.)

R11	Resistor, Variable 500	80294	3292P-1-501	83195005
R12	Resistor Metal Oxide 1K 1/8W 1%	07716	CEA-TO	83049192
R13	See R12			
C1	Capacitor, 100pf	72136	DM15E101J0500 WV4CR	80115027
C2	See C1			
C3	See C1			
U1	Integrated Circuit	07263	LM208A	84728000
U2	See U1			
U3	See U1			